Stabilite® 2018

Ion Laser

User's Manual

Spectra-Physics
Spectra-Physics Lasers

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Preface

This manual contains information you need in order to safely install, align, operate, maintain, and service your Stabilite® 2018 laser system. The system comprises three elements: the Stabilite 2018 laser head, the Model 2550 power supply and the Model 2670 remote control. The latter is a table-top controller that is provided with the system for local control. If computer control is required, an optional Model 2680 computer interface is available.

The "Introduction" contains a brief description of the Stabilite 2018 system and includes a short section on laser theory regarding argon and krypton ion lasers. The end of the chapter contains system specifications.

Following that section is an important chapter on laser safety. The Stabilite 2018 is a Class IV laser and, as such, emits laser radiation which can permanently damage eyes and skin. This section contains information about these hazards and offers suggestions on how to safeguard against them. To minimize the risk of injury or expensive repairs, be sure to read this chapter—then carefully follow these instructions.

The middle chapters describe the Stabilite 2018 controls and indicators, then guide you through its installation and operation. Separate chapters cover the Model 2670 remote control and the optional Model 2680 computer interface. The last part of the manual covers maintenance and service, and it includes a replacement parts list and a list of world-wide Spectra-Physics Lasers Service Centers you can call if you need help.

Whereas the "Maintenance" section contains information you need to keep your laser clean and operational on a day-to-day basis, "Service and Repair" is intended to help you guide your Spectra-Physics Lasers field service engineer to the source of any problems. *Do not attempt repairs yourself while the unit is still under warranty*; instead, report all problems to Spectra-Physics Lasers for warranty repair.

This product has been tested and found to conform to "Directive 89/336/EEC for Electromagnetic Compatibility." Class A compliance was demonstrated for "EN 50081-2: 1993 Emissions" and "EN 50082-1: 1992 Immunity" as listed in the official *Journal of the European Communities*. It also meets the intent of "Directive 73/23/EEC for Low Voltage." Class A compliance was demonstrated for "EN 61010-1: 1993 Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use" and "EN 60825-1: 1992 Radiation Safety for Laser Products." Refer to the "EC Declaration of Conformity" statements in Chapter 2.

Finally, if you encounter any difficulty with the content or style of this manual, please let us know. The last page is a form to aid in bringing such problems to our attention.

Thank you for your purchase of Spectra-Physics Lasers instruments.

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Warning Conventions

The following warnings are used throughout this manual to draw your attention to situations or procedures that require extra attention. They warn of hazards to your health, damage to equipment, sensitive procedures, and exceptional circumstances. All messages are set apart by a thin line above and below the text as shown here.

Laser radiation is present.

Danger!

Conditions or action may cause injury or present a hazard to personal safety.

Warning!

Condition or action may cause damage to equipment.

Caution!

Condition or action may cause poor performance or error.

Note

Text describes exceptional circumstances or makes a special reference.

Don't Touch!

Do not touch.

Eyewear Required

Appropriate laser safety eyewear should be worn during this operation.

Standard Units

The following units, abbreviations, and prefixes are used in this Spectra-Physics Lasers manual:

Quantity	Unit	Abbreviation
angle	radian	rad
area	square meter	m^2
capacitance	farad	F
electric charge	coulomb	C
electric current	ampere	A
electric potential	volt	V
energy	joule	J
force	newton	N
frequency	hertz	Hz
inductance	henry	H
length	meter	m
luminous intensity	candela	cd
magnetic flux	weber	Wb
magnetic flux density	tesla	T
mass	gram	g
power	watt	W
pressure	pascal	Pa
resistance	ohm	Ω
temperature	kelvin	K
time	second	s
volume	cubic meter	m^3

Prefixes

tera	(10^{12})	T	deci	(10^{-1})	d	nano	(10^{-9})	n
giga	(10^{9})	G	centi	(10^{-2})	c	pico	(10^{-12})	p
mega	(10^{6})	M	milli	(10^{-3})	m	femto	(10^{-15})	f
kilo	(10^{3})	k	micro	(10^{-6})	μ	atto	(10^{-18})	a

Unpacking and Inspection

Your laser was packed with great care and its containers inspected prior to shipment. It left Spectra-Physics Lasers in good condition. Upon receiving your laser, immediately inspect the outside of the shipping containers. If there is any major damage (holes in the containers or cracked wooden frame members), insist that a representative of the carrier be present when you unpack the contents.

Carefully inspect your laser as you unpack it. If you notice any damage, such as dents or scratches on the cover, or broken knobs, immediately notify the carrier and your Spectra-Physics Lasers sales representative.

Keep the shipping containers. If you file a damage claim, you may need the containers to demonstrate that the damage occurred as a result of shipping. If you need to return the laser for service, these specially designed crates assure adequate protection.

Warning!

Spectra-Physics Lasers considers itself responsible for the safety, reliability, and performance of the Stabilite® 2018 only under the following conditions:

- All field installable options, modifications, or repairs are performed by persons trained and authorized by Spectra-Physics Lasers.
- The equipment is used in accordance with the instructions provided in this manual.

System Components

- Stabilite 2018 laser head
- Model 2550 power supply with optional Model 2680 computer interface (if ordered)
- Model 2670 remote control

Accessory Kit

Included with the laser system is this manual, a packing slip listing all the components shipped with this order, and an accessory kit containing the following items:

- two hoses (cooling system water supply and return lines)

- a water filter with two extra filter cartridges
- plumbing fittings for connecting the water filter (provided) into the system supply line
- a tool kit containing 3/32 in. ball drivers for optimizing laser output and a 5/32 in. ball driver for adjusting the height of the laser
- a plastic hemostat
- a packet of Kodak Lens Cleaning Paper™
- a prism assembly
- keys (2) for the Model 2670 remote control
- 50 A fuses (3) for the power supply
- various small, medium-current fuses (8) for the power supply
- any optional optics that were ordered

You will need to supply several items, including:

- spectrophotometric-grade (HPLC) acetone and methanol for optics cleaning
- clean, lint-free finger cots or powder-less latex gloves for optics cleaning

Chapter 1 Introduction

A Brief Review of Ion Laser Theory

*Emission and Absorption of Light**

Laser is an acronym derived from Light Amplification by Stimulated Emission of Radiation. Thermal radiators, such as the sun, emit light in all directions, the individual photons having no definite relationship with one another. But because the laser is an oscillating amplifier of light, and because its output comprises photons that are identical in phase, direction, and amplitude, it is unique among light sources. Its output beam is singularly directional, intense, monochromatic, and coherent.

Radiant emission and absorption take place within the atomic or molecular structure of materials. The contemporary model of atomic structure describes an electrically neutral system composed of a nucleus with one or more electrons bound to it. Each electron occupies a distinct orbital that represents the probability of finding the electron at a given position relative to the nucleus. Each orbital has a characteristic shape that is defined by the radial and angular dependence of that probability, e.g., all *s* orbitals are spherically symmetrical, and all *p* orbitals surround the x, y, and z axes of the nucleus in a double-lobed configuration (Figure 1-1). The energy of an electron is determined by the orbital that it occupies, and the over-all energy of an atom—its energy level—depends on the distribution of its electrons throughout the available orbitals. Each atom has an array of energy levels: the level with the lowest possible energy is called the ground state, and higher energy levels are called excited states. If an atom is in its ground state, it will stay there until it is excited by an external source.

Movement from one energy level to another—a transition—happens when the atom either absorbs or emits energy. Upward transitions can be caused by collision with a free electron or an excited atom, and transitions in both directions occur as a result of interaction with a photon of light. Consider a transition from a lower level whose energy content is E_1 to a higher one with energy E_2. It will only occur if the energy of the incident photon matches the energy difference between these levels, i.e.,

$$h\nu = E_2 - E_1 \qquad [1]$$

where h is Planck's constant and ν is the frequency of the photon.

** "Light" will be used to describe the portion of the electromagnetic spectrum from far infrared to ultraviolet.*

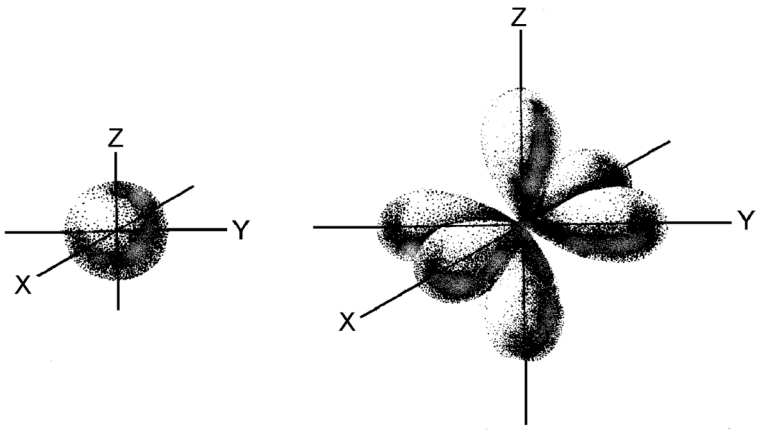


Figure 1-1: Electrons occupy distinct orbitals defined by the probability of finding an electron at a given position, the shape of the orbital being determined by the radial and angular dependence of the probability.

Likewise, when an atom excited to E_2 decays to E_1, it loses energy equal to $E_2 - E_1$. Because its tendency is toward the lower energy state, the atom may decay spontaneously, emitting a photon with energy $h\nu$ and frequency

$$\nu = (E_2 - E_1)/h. \qquad [2]$$

Spontaneous decay can also occur without emission of a photon, the lost energy taking another form, e.g., transfer of kinetic energy by collision with another atom. An atom excited to E_2 can also be stimulated to decay to E_1 by interacting with a photon of frequency ν, shedding energy in the form of a pair of photons that are identical to the incident one in phase, frequency, and direction. By contrast, spontaneous emission produces photons that have no directional or phase relationship with one another.

A laser is designed to take advantage of absorption, and both spontaneous and stimulated emission phenomena, using them to create conditions favorable to light amplification. The following paragraphs describe these conditions.

Population Inversion

The absorption coefficient at a given frequency is the difference between the rates of emission and absorption at that frequency. It can be shown that the rate of excitation from E_1 to E_2 is proportional to both the number of atoms in the lower level (N_1) and the transition probability. Similarly, the rate of stimulated emission is proportional to the population of the upper level (N_2) and the transition probability. Moreover, the transition probability depends on the flux of the incident wave and a characteristic of the transition called its “cross section.” It can also be shown that the transition cross section is the same regardless of direction. Therefore, the absorption coefficient depends only on the difference between the populations involved, N_1 and N_2, and the flux of the incident wave.

When a material is at thermal equilibrium, a Boltzmann distribution of its atoms over the array of available energy levels exists with nearly all atoms in the ground state. Since the rate of absorption of all frequencies exceeds that of emission, the absorption coefficient at any frequency is positive.

If enough light of frequency ν is supplied, the populations can be shifted until $N_2 = N_1$. Under these conditions the rates of absorption and stimulated emission are equal, and the absorption coefficient at frequency ν is zero. If the transition scheme is limited to two energy levels, it is impossible to drive the populations involved beyond equality; that is, N_2 can never exceed N_1 because every upward transition is matched by one in the opposite direction.

However, if three or more energy levels are employed, and if their relationship satisfies certain requirements described below, additional excitation can create a population inversion, in which $N_2 > N_1$.

A model four-level laser transition scheme is depicted in Figure 1-2 (a).

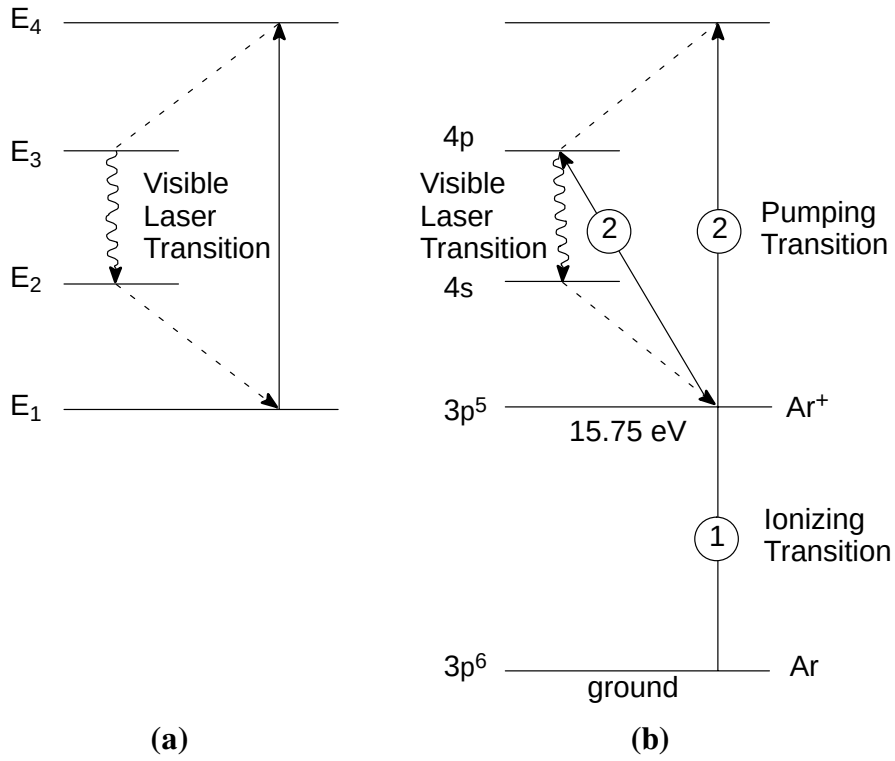


Figure 1-2: A typical four-level laser transition scheme (a) compared to that of visible argon (b). One electron collision ionizes neutral argon, and a second pumps the ion to an excited state.

A photon of frequency ν_1 excites—or "pumps"—an atom from E_1 to E_4. If the E_4 to E_3 transition probability is greater than that of E_4 to E_1, and if E_4 is unstable, the atom will decay almost immediately to E_3. If E_3 is metastable, i.e., atoms that occupy it have a relatively long lifetime, the population will grow rapidly as excited atoms cascade from above. The E_3 atom will eventually decay to E_2, emitting a photon of frequency ν_2. Finally, if E_2 is unstable, its atoms will rapidly return to the ground state, E_1, keeping the population of E_2 small and reducing the rate of absorption of ν_2. In this way the population of E_3 is kept large and that of E_2 remains low, thus establishing a population inversion between E_3 and E_2. Under these conditions, the absorption coefficient at ν_2 becomes negative. Light is amplified as it passes through the material, which is now called an "active medium," and the greater the population inversion, the greater the gain.

A four-level scheme has a distinct advantage over three-level systems, where E_1 is both the origin of the pumping transition and the terminus of the lasing transition. In the four-level arrangement, the first atom that is pumped contributes to the population inversion, whereas over half of the atoms must be pumped from E_1 before an inversion is established in the three-level system.

In commercial laser designs the source of excitation energy is usually optical or electrical: arc lamps are often employed to pump solid-state lasers; the output of one laser can be used to pump another, e.g., a liquid dye laser is often pumped by an ion laser; and an electric discharge is generally used to excite a gaseous media like argon or krypton.

Argon as an Excitation Medium

The properties of argon are probably the best understood of all the ionized gas laser media. Its transition scheme is similar to the model in Figure 1-2(b), and its visible energy level diagram is depicted in Figure 1-3. The neutral atom is pumped to the 4p energy level—the origin of the lasing transition—by two collisions with electrons. The first ionizes the atom, and the second excites the ion from its ground state (E_1) either directly to the 4p energy level (E_3) or to E_4, from which it cascades almost immediately to 4p. The 4p ions will eventually decay to 4s (E_2), emitting a photon either spontaneously or when stimulated to do so by a photon of equivalent energy. The wavelength of the photon depends on the specific energy levels involved, but it will be between 400 and 600 nm. The ion decays spontaneously from 4s to the ionic ground state, emitting a photon in the vacuum ultraviolet (uv)—about 74 nm—as it leaves the lower level of the lasing transition.

The population in the ionic ground state at any given time is small. Recombination processes return ions to the neutral atom energy level scheme; therefore, there is no tendency toward a self-absorption "bottleneck," a population buildup in the lower laser levels.

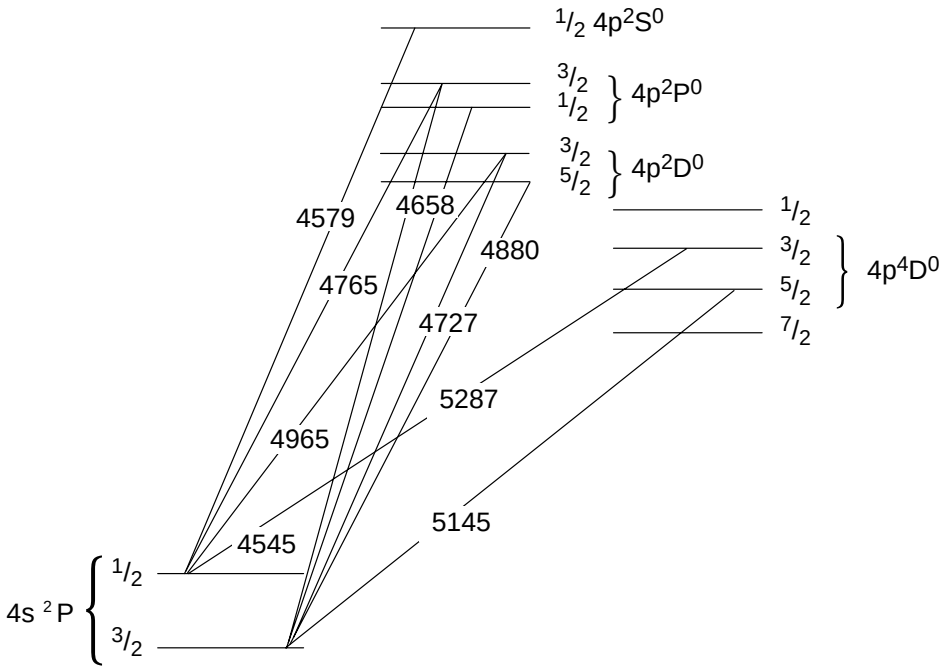


Figure 1-3: Energy Levels of the 4p – 4s Argon Ion Laser Transitions

The existence of only two lower states for a large number of visible laser transitions suggests that strong competition between lines with a common lower level may exist. Such competition would manifest itself as improved performance of a given line during single-line operation, compared to its strength when all lines are present. Although competition exists, its effect is minor, and single-line operation improves the power of principal lines by less than 10%. Even those upper state populations that are shared by more than one laser transition only exhibit minor competition effects. Therefore, the use of a prism or other dispersing element in continuous-wave (cw) argon ion lasers is not necessarily advantageous, except in single-line applications.

Ion laser gain is directly affected by several factors including discharge current density, magnetic field, and gas pressure. Since two collisions with free electrons are required to pump an argon atom to the upper level of visible lasing transitions, the gain of the medium varies as the square of the current density. Below saturation, the multimode, all-lines output of an ion laser can be expressed as

$$P = kJ^2V \qquad [3]$$

where P is the output power, J is the current density (A/cm^2), V is the volume of the active medium, and k is a constant.

A magnetic field enveloping the plasma discharge enhances the population inversion. It tends to force free electrons toward the center of the plasma tube bore, thus increasing the probability of a pumping collision. Unfortunately, the magnetic field also causes Zeeman splitting of the laser lines, which elliptically polarizes the output, causing partial loss at the polarization-sensitive plasma tube windows. Susceptibility to the Zeeman effect varies from line to line, and each has an optimum magnetic field strength.

Krypton laser transitions do not have as much gain as argon transitions, and are generally less powerful. Krypton lasers exhibit emission across a broader visible spectrum than do argon lasers, and are often attractive for this reason. The primary wavelength from a krypton laser is the strong red line at 647.1 nm, and although there are other significant lines in the blue, green, yellow, red, and near infrared (ir) regions, krypton lasers are nominally referred to by the optical output power of the 647.1 nm line.

The Resonant Optical Cavity

A resonant cavity defined by two mirrors provides feedback to the active medium. Photons emitted parallel to the cavity axis are reflected, returning to interact with other excited ions. Stimulated emission produces two photons of equal energy, phase, and direction from each interaction. The two become four, four become eight, and the numbers continue to increase geometrically until an equilibrium between excitation and emission is reached.

Both mirrors are coated to reflect the wavelength, or wavelengths, of interest while transmitting all others. One of the mirrors, the output coupler, transmits a fraction of the energy stored within the cavity, and the escaping radiation becomes the output beam of the laser.

For broadband, or “all-lines,” operation the mirrors reflect a number of lines within a limited wavelength range (about 70 nm maximum).

Adding a prism to the cavity limits oscillation to a single line. The dispersion of the prism allows only one line to be perfectly aligned with the high reflector, so the tilt of the prism determines which line will oscillate.

The laser oscillates within a narrow range of frequencies around the transition frequency. The width of the frequency distribution, the “linewidth,” and its amplitude depend on the gain medium, its temperature, and the magnitude of the population inversion.

Linewidth is determined by plotting the gain of each frequency and measuring the width of the curve where the gain has fallen to one half maximum (“full width at half maximum,” Figure 1-4).

Line broadening depends on the relative velocities of the excited ions as they radiate. If the ion is stationary at the time of stimulated emission, the product photons will possess exactly the transition frequency. If the ion is moving toward the stimulating photon, the resultant frequency will be higher than that of the transition; likewise, if the ion is moving away, the frequency will be lower.

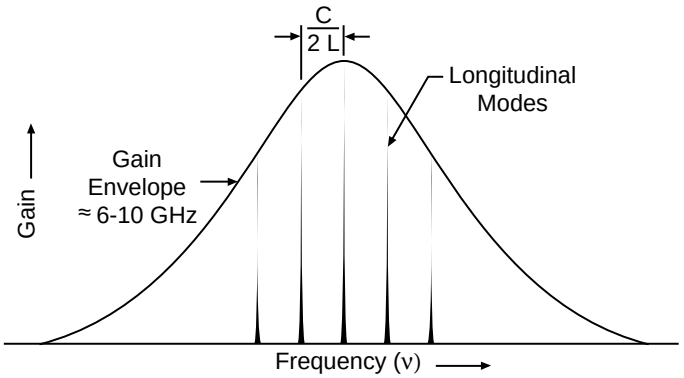


Figure 1-4: Frequency Distribution of Longitudinal Modes for a Single Line

The output of the laser is discontinuous within this Doppler broadened line profile. A standing wave propagates within the optical cavity, and any frequency that satisfies the resonance condition

$$\nu_m = mc/2L \qquad [4]$$

will oscillate, where ν_m is the frequency, c is the speed of light, L is the optical cavity length, and m is an integer. Thus, the output of a given line is a set of discrete frequencies—called "longitudinal modes"—spaced such that

$$\Delta\nu = c/2L. \qquad [5]$$

Power Performance Considerations

Several factors influence ion laser output. The optical power can be calculated from

$$P_o = TAI_s \left(\frac{2\alpha_o L}{T+\beta} - 1 \right) \qquad [6]$$

where T is the output coupler transmission, A is the cross-sectional area of the beam, I_s is a saturation parameter, α_o is the small signal gain, L is the gain length, and β is the sum of all cavity losses.

The transmission of the output coupler should be the greatest of the cavity losses: it should be greater than the sum of all others. Ideally β, which is caused by unwanted absorption, reflection, diffraction, and transmission, should be zero. Cleanliness of plasma tube processing operations, which eliminates contaminants that can find their way to the inside surfaces of the mirrors, is essential to improved ion laser output. Cleanliness of other cavity elements, including both mirrors and the outside window surfaces, is also very important. A sealed cavity with an incorporated intracavity passive catalyst contributes to overall performance by minimizing the effect of ozone on the window surface.

System Description

The following components comprise the Stabilite 2018 general purpose ion laser:

- Stabilite 2018 laser head
- Model 2550 power supply
- Model 2670 remote control

Optional accessories for the Stabilite 2018 include:

- Model 2680 computer interface
- Optics set for 413 nm operation

Stabilite 2018 Laser Head

The Stabilite 2018 laser head employs a brass cylinder for use as a coaxial resonator. The resonator defines the optical cavity and provides cavity stability to prevent changes in output power. Its design is also critical for good beam-pointing stability.

The cylinder also serves as the outer jacket for the water cooling system where it provides high thermal conductivity and excellent rigidity. The brass material, cylindrical configuration, and helical flow of the cooling water create a “thermal short,” preventing the occurrence of thermal gradients that might otherwise distort the resonator.

The output coupler and high reflector are mounted in mirror plates attached to the ends of the resonator. The high reflector plate features interchangeable broadband optic and prism assemblies for single-line or multiline operation.

To avoid the disruptive effects of stress and vibration on the optical cavity, the resonator is mechanically isolated from its environment. The feet and base of the laser head support the magnet while two o-rings, one at each end, decouple the resonator from the magnet.

This unique, stable, resonator design allows the output of the Stabilite 2018 to be optimized using only two controls: the fine horizontal and vertical controls on the high reflector mirror plate. These controls allow the user to maintain optimal mirror alignment, and when the prism assembly is installed, the course vertical control allows the single-line wavelength range to be scanned.

The metal-ceramic and Q-M Endbells™ construction of the plasma tube are possible due to Spectra-Physics Lasers’ clean room manufacturing practices. This design results in a rugged, reliable, high-performance plasma tube.

Inside the tube, heat-resistant tungsten disks confine the plasma discharge to an optimal diameter, and copper webs link the super-heated disks to the ceramic envelope where the heat is dissipated into the cooling water.

Tungsten is used for the bore elements because of its high melting point and resistance to sputtering under high current densities. These properties minimize erosion of the bore, and a constant bore size is necessary to keep beam diameter, mode quality, and output power constant over the lifetime of the tube.

Class 100 clean room manufacturing conditions result in a plasma tube that is free of internal contamination. All tubes are evacuated at high temperatures to drive out residual contaminants. Residual gas analysis is used to monitor plasma tubes during processing to ensure cleanliness. A scanning electron microscope/energy dispersive spectrometer is used to check parts and processes for contamination. Such monitoring provides immediate feedback on plasma tube cleanliness.

Q-M Endbells technology is a Spectra-Physics innovation that extends plasma tube lifetime. A patented coating protects the windows from long-term uv radiation damage, and a modified optical contact bond is used to seal the window to the endbell assembly, essentially eliminating residual contamination inherent in conventional “hard seal” bonding agents. Q-M Endbells are sturdy enough to withstand high temperature processing methods. This produces a window that remains free of internal deposits that degrade performance.

An automatic gas fill system monitors the gas pressure in the plasma tube and meters precise volumes of gas from a high pressure reservoir whenever pressure falls below the optimal range. The reservoir is located on the plasma tube. This automatic fill feature contributes to the dependability and convenience of the Stabilite 2018 ion laser.

The Stabilite 2018 does not require a cavity purge. Instead, an intracavity passive catalyst placed inside each cavity seal minimizes contaminating ozone (O_3) by converting it to molecules of harmless oxygen (O_2). This design eliminates the requirement for the typical gas supply, filters, driers, and air tubing.

Model 2550 Power Supply

The power supply provides ample low-noise current for the plasma discharge. To keep the power supply compact, cost effective, and efficient, patented Spectra-Physics Lasers switched resistor technology and a pass-bank are used for its regulator.

To comply with FCC Class A and VDE 0871A conducted emissions standards, an EMI filter is included. It minimizes emissions and any associated interference with sensitive laboratory equipment.

Model 2670 Remote Control

This small, table-top remote control operates through an analog/TTL interface on the power supply for convenient control of the laser system. A user-supplied control module can also operate the system through this interface. Pin-out and electrical specifications for this interface are listed in Chapter 6. Note, however, that repair for power supply damage resulting from the use of a remote control device other than the Model 2670 or the optional Model 2680 computer interface is not covered under warranty.

Optional Model 2680 Computer Interface

The optional Model 2680 computer interface provides standard digital control either through the serial RS-232-C or the parallel IEEE 488 interfaces. This allows the system to be operated remotely using either a computer or a terminal.

Stabilite 2018 Specifications

Table 1-1: Laser Performance Specifications

Output characteristics	Specification
All Lines Output Power	2.5 W
Single–Line Output Power (nm)	
647.1	300 mW
568.2	150 mW
530.9	200 mW
520.8	100 mW
514.5	250 mW
488.0	250 mW
476.5	150 mW
Beam Diameter[2], at $^1/_e{}^2$ points	1.8 mm ±10%
Beam Divergence[3], full angle	0.70 mrad ±10%
Polarization	≥ 100:1 vertical
Noise[4],	
Current Mode	≤ 0.5% rms
Power Mode	≤ 0.5% rms
Stability[5]	
Current Mode	±1.0%
Power Mode	±0.5%
Beam Pointing Stability[6]	≤ 7.5 µrad/˚C

[1] Due to our continuous product improvement program, specifications may change without notice.

[2] Specification for 647.1 nm (krypton). For other wavelengths, assuming no change in optical configuration, the diameter is given by $dia_1/dia_2 = \sqrt{\lambda_1/\lambda_2}$.

[3] Data is for 514.5 nm for argon, 647.1 nm for krypton.

[4] Specification represents rms noise at 647.1 nm (krypton), measured in a 10 Hz to 2 MHz bandwidth.

[5] Specification applies for any 30-minute period after a 2-hour warm-up.

[6] Specification applies after a 2-hour warm-up.

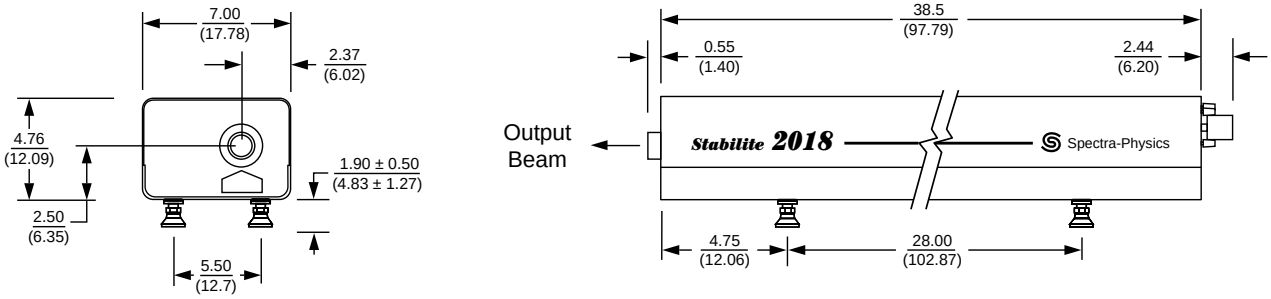
Table 1-2: Laser Mechanical Specifications

Power Requirements	
Voltage	208 Vac ±10%, 50/60 Hz
Phase	3-phase with ground
Current (max)	45 A per phase @ 208 Vac
Power Consumption	16 kW
Water Requirements	
Flow Rate	6.5 lpm (1.7 gpm)
Pressure	138 – 689 kPa (20 – 100 psi)
Temperature (at inlet)	10 – 35˚C (50 – 95˚F)
pH Level	7.0 to 8.5
Hardness (max)	<100 ppm dissolved solids
Particulate Size	<200 µm dia.

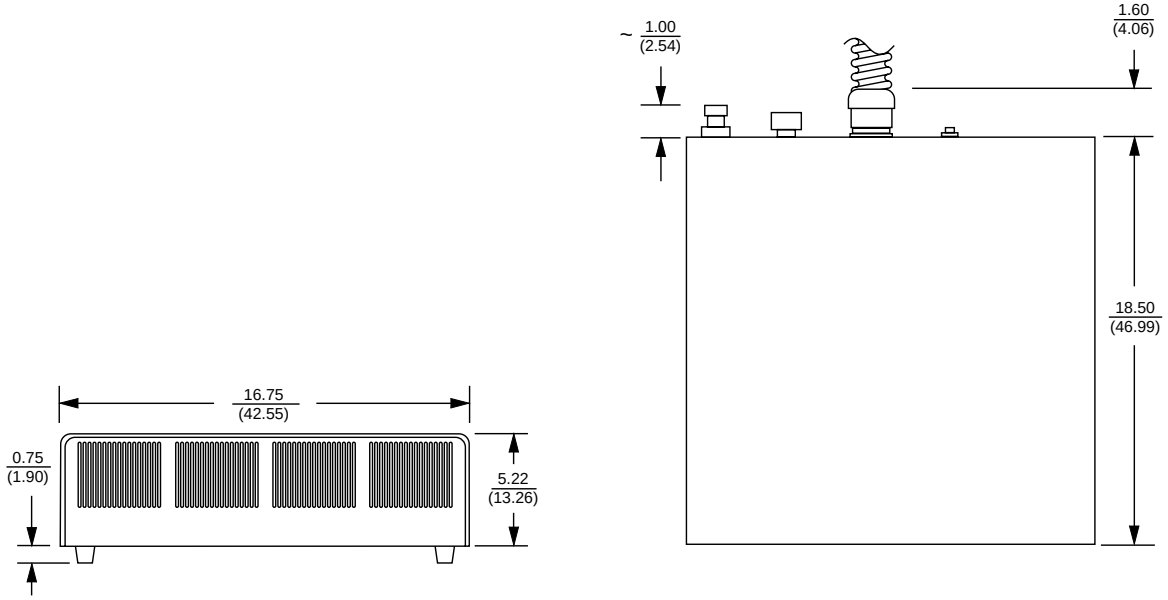
Table 1-2: Laser Mechanical Specifications (Cont.)

Power Dissipation	
Into Water	16 kW (910 Btu/min)
Into Air	150 W (9 Btu/min)
Weight	
Laser Head	95.5 kg (210 lbs)
Power Supply	32 kg (70 lbs)
Umbilical length	3 m (9 ft)
Power cord length	3 m (9 ft)
Hose length	3 m (9 ft)

Outline Drawings



Stabilite® 2018 Laser Head



Model 2550 Power Supply

All dimensions in *inches* / *(cm)*

Chapter 2 Laser Safety

The Spectra-Physics Lasers Stabilite 2018 is a Class IV—High Power Laser whose beam is, by definition, a safety and fire hazard. Take precautions to prevent accidental exposure to both direct and reflected beams. Diffuse as well as specular beam reflections can cause severe eye or skin damage.

Precautions for the Safe Operation of Class IV-High Power Lasers

- Wear protective eyewear at all times; selection depends on the wavelength and intensity of the radiation, the conditions of use, and the visual function required. Protective eyewear is available from vendors listed in the *Laser Focus World, Lasers and Optronics,* and *Photonics Spectra* buyer's guides. Consult the ANSI, ACGIH, or LIA standards listed at the end of this section for guidance.
- Keep the protective cover on the laser head at all times.
- Avoid looking at the output beam; even diffuse reflections are hazardous.
- Operate the laser at the lowest beam intensity possible, given the requirements of the application.
- Expand the beam whenever possible to reduce beam intensity.
- Avoid intercepting the output beam or its reflection with any part of the body.
- Establish a controlled-access area for laser operation. Limit access only to those persons trained in laser safety principles.
- Maintain a high ambient light level in the laser operation area so the eye's pupil remains constricted, reducing the possibility of damage.
- Post prominent warning signs near the laser operation area (Figure 2-1).
- Set up experiments so the laser beam is either above or below eye level.
- Provide enclosures for beam paths whenever possible.
- Set up shields to prevent unnecessary specular reflections.

- Set up an energy absorbing target to capture the laser beam, preventing unnecessary reflections or scattering (Figure 2-2).

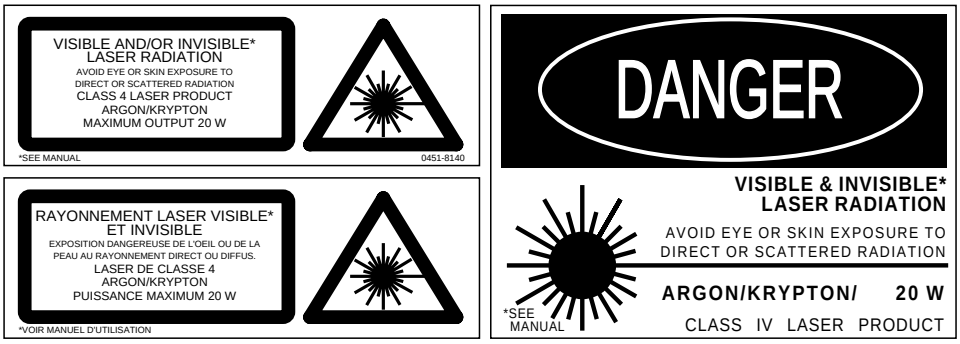


Figure 2-1: These CE and CDRH standard safety warning labels would be appropriate for use as entry warning signs (EN 60825-1, ANSI 4.3.10.1).

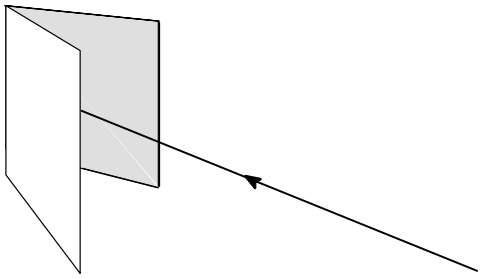


Figure 2-2: Folded Metal Beam Target

Caution!

Use of controls or adjustments, or performance of procedures other than those specified herein may result in hazardous radiation exposure.

Follow the instructions contained in this manual for safe operation of your laser. At all times during operation, maintenance, or service of your laser, avoid unnecessary exposure to laser or collateral radiation* that exceeds the accessible emission limits listed in "Performance Standards for Laser Products," *United States Code of Federal Regulations*, 21CFR1040 10(d).

* *Any electronic product radiation, except laser radiation, emitted by a laser product as a result of, or necessary for, the operation of a laser incorporated into that product.*

Laser Head and Power Supply Cover Interlocks

The Stabilite 2018 has safety interlocks for both the laser head cover and power supply cover. Removing either of these covers causes the main power contactor to open, shutting off electrical power to the laser. The covers must be in place or their interlocks defeated before the laser will operate.

Danger!

Both the laser head and power supply contain electrical circuits operating at lethal voltage and current levels. Be extremely careful whenever the cover is removed from either unit. Avoid contact with high voltage terminals and components.

Danger!
Laser Radiation

While the laser head cover is removed, be extremely careful to avoid exposure to laser or collateral radiation.

Installing the safety interlock key in the laser head (Figure 2-3) allows the laser to operate with its cover removed.

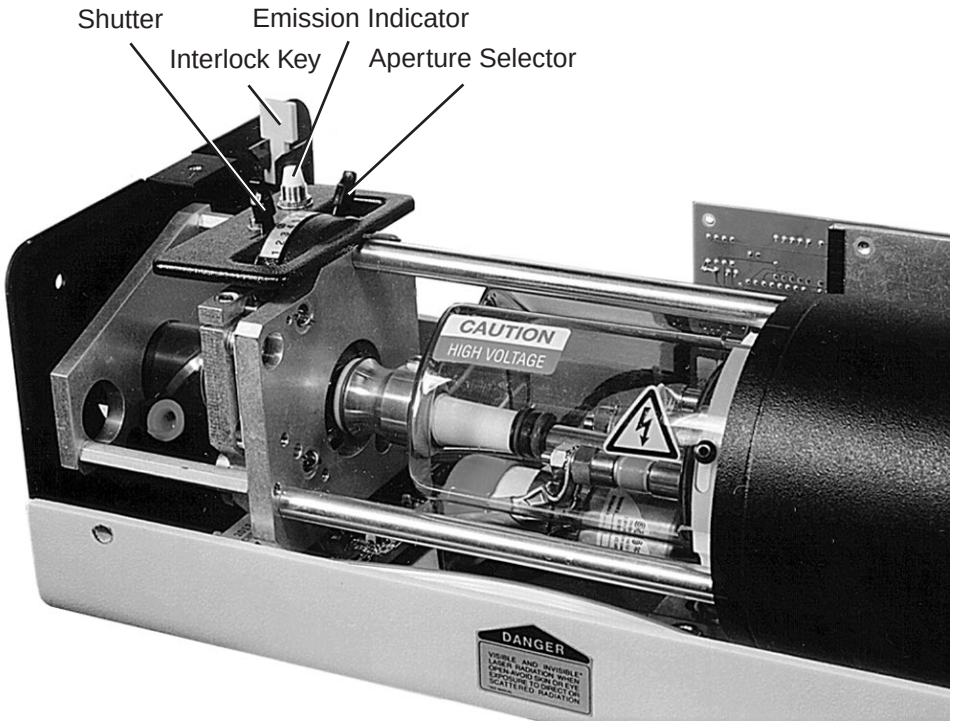


Figure 2-3: Stabilite 2018 laser head safety interlock key, emission indicator, shutter and aperture.

The laser head cover cannot be replaced until the safety interlock key has been removed. Shut off the laser before removing the interlock key and/or replacing the cover.

Pulling up the power supply cover interlock switch (Figure 2-4) allows the power supply to operate with its cover removed. Be extremely careful to avoid contact with high voltage if operating the system with the cover off.

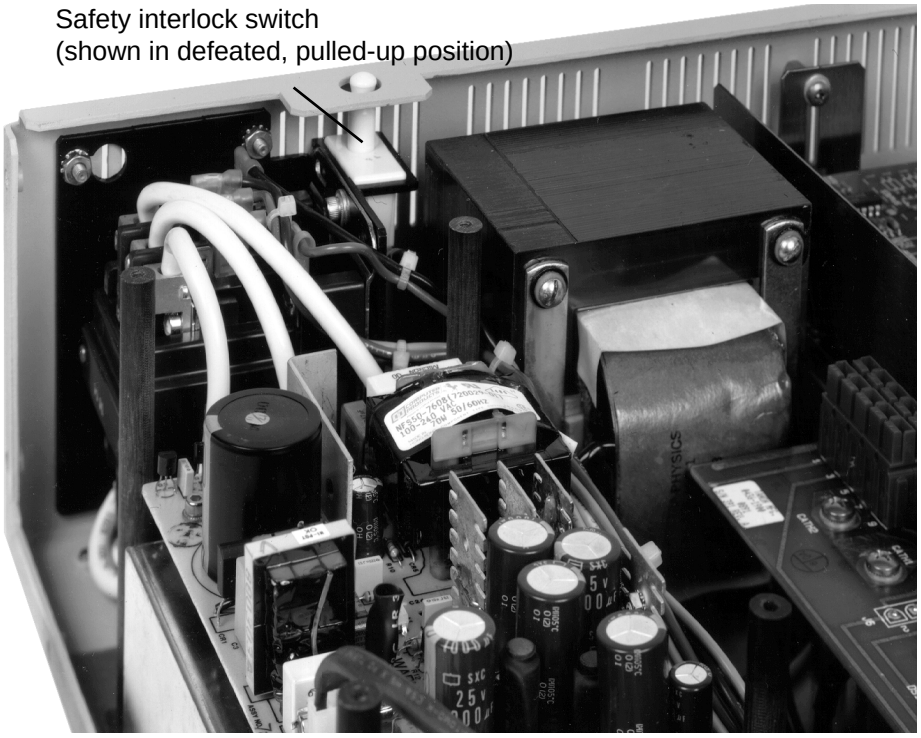


Figure 2-4: Power supply safety interlock switch.

Maintenance Necessary to Keep this Laser Product in Compliance with Center for Devices and Radiological Health (CDRH) Regulations

This laser product complies with Title 21 of the *United States Code of Federal Regulations*, Chapter 1, Subchapter J, Parts 1040.10 and 1040.11, as applicable. To maintain compliance with these regulations, once a year or whenever the product has been subjected to adverse environmental conditions (e.g., fire, flood, mechanical shock, spilled solvent), check to see that all features of the product identified on the radiation control drawing (Figure 2-6) properly. Also, make sure that all warning labels remain firmly attached.

1. Verify that removing the AUX INTLK plug from the Model 2670 remote control prevents laser operation.

2. Verify that the laser will only operate with the remote control key switch in the ON position, and that the key can only be removed when the switch is in the OFF position.
3. Verify that the emission indicator provides a visible signal when the laser emits accessible laser radiation that exceeds the accessible emission limits for Class I*.
4. Verify that a time delay exists between the turn-on of the emission indicator and the starting of the laser; it must give enough warning to allow action to avoid exposure to laser radiation.
5. Verify that the beam attenuator (laser head shutter) actually blocks exposure to laser radiation.
6. Verify that removing either the laser head or power supply cover shuts off the laser.
7. Verify that, when either the laser head or power supply cover interlock is defeated, Figure 2-3 and Figure 2-4, the defeat mechanism is clearly visible and prevents installation of the cover until disengaged.

CDRH Requirements for a Custom Remote Control or for Operation with the Optional Model 2680 Computer Interface

The Stabilite 2018 laser head and the Model 2550 power supply comply with all CDRH safety standards when operated with the Model 2670 remote control provided with the system. However, when the laser and power supply are operated without the remote control through either the optional Model 2680 computer interface or a user-supplied system, you must provide the following in order to satisfy CDRH regulations:

Key Switch—to limit laser access. It can be a real key lock, a removable computer disk, a password that limits access to computer control software, or similar implement. The laser must be capable of operation only when the “key” is present and in the “on” position.

Emission Indicator—to indicate that laser energy is, or can be, accessible. It can be a “power-on” lamp, computer display, or similar indicator on the control equipment. It need not be marked as an emission indicator so long as its function is obvious. Its presence is required on any control panel that affects laser output.

Remote Interlock Connector—to prevent laser operation when the remote control device is removed. A jumper between pins 23 and 24 on the REMOTE connector is required for operation.

* *0.39 μW for continuous-wave operation where output is limited to the 400 to 1400 nm range.*

Operation with the Prism Cover Off

Danger!
Laser Radiation

If the prism assembly is installed with its cover off, a portion of the intracavity beam is reflected upward from each face of the prism (Figure 2-5). Avoid eye contact with these beams.

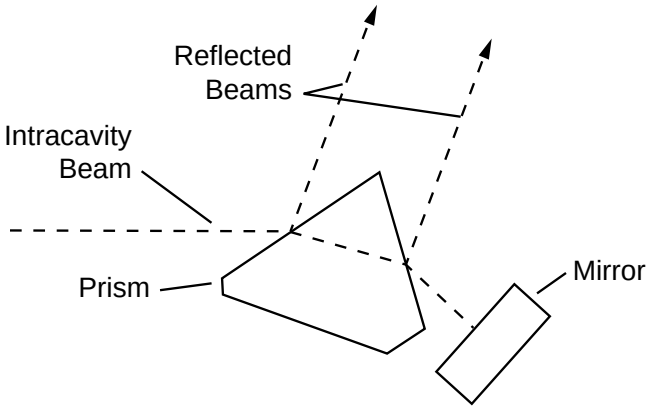
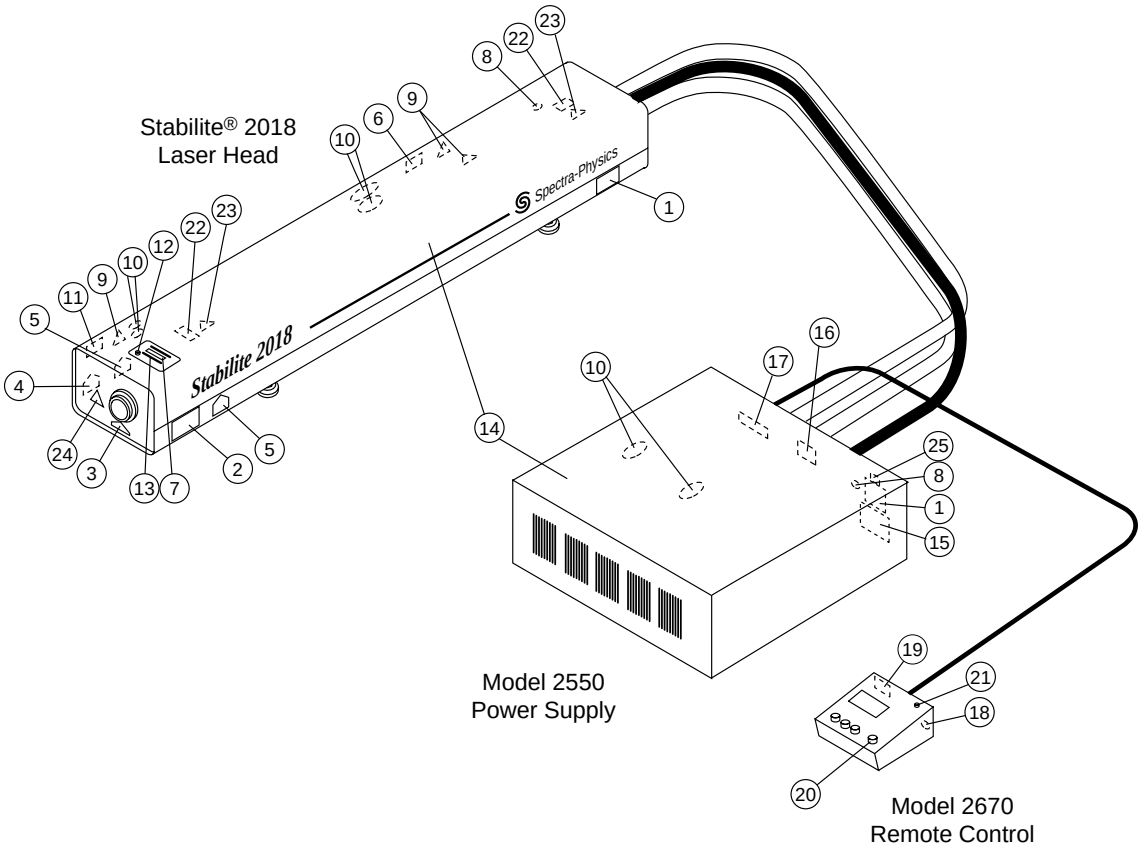
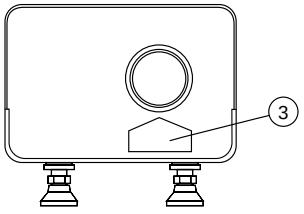


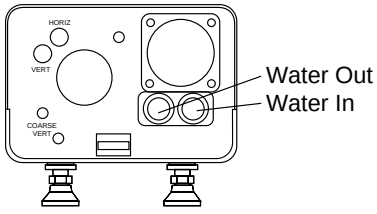
Figure 2-5: A portion of the intracavity beam is reflected upward from each face of the prism.

Radiation Control Drawings





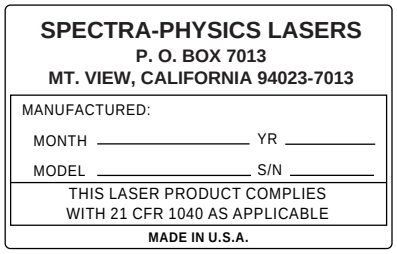
Output End View



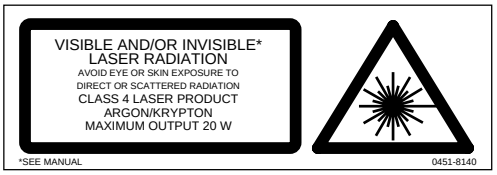
Rear Panel View

1 Certification & Identification Label
2 Danger Class IV Warning Logo Label
3 Aperture Label
4 Danger Interlocked Housing Label
5 Danger When Open Label
6 Danger Cavity Seal Label
7 Aperture, Shutter, Beam Diameter Label
8 Ground Label
9 Lightning Bolt Label, Large
10 European High Voltage Label
11 Head Cover Interlock Switch
12 Emission Indicator Light (Laser Head)
13 Mechanical Shutter
14 Top Cover (Protective Housing)
15 Configuration Label
16 Patent Label
17 Remote Connector (Includes Interlock)
18 Interlock Shorting Cap
19 Serial Label, Remote Control
20 Key Switch (On/Off)
21 Emission Indicator Light (Remote Control)
22 Caution High Voltage Label
23 Lightning Bolt Label, Small
24 CE Aperture Label
25 European Conformity Label

Figure 2-6: Stabilite 2018 Radiation Control Drawing (Labels Next Page)



Certification and Identification Label (1)

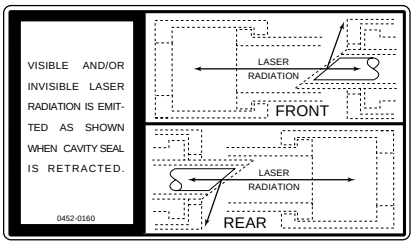


CE Danger Class IV Warning Label (2)

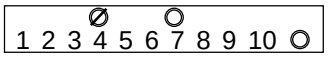
Aperture Label (3)

Danger Interlocked Housing Label (4)

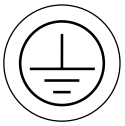
Danger When Open Label (5)



Danger Cavity Seal Label (6)

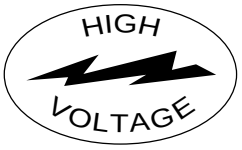


Aperture, Shutter Beam Diameter Label (7)

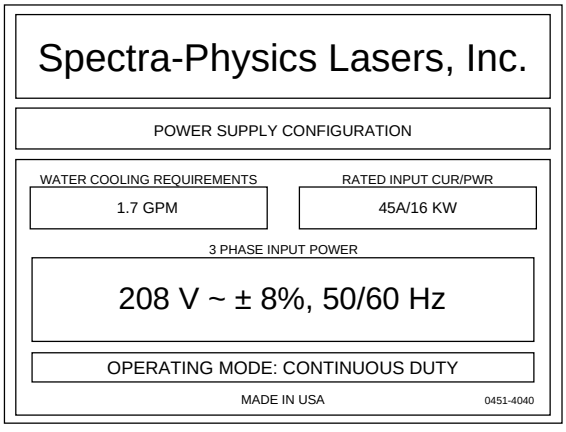


Ground Label (8)

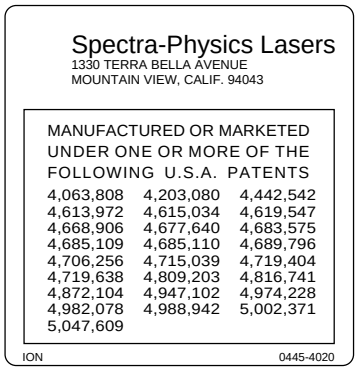
Lightning Bolt Label (9)(23)



European High Voltage Label (10)



Configuration Label (15)



Patent Label (16)

Identification Label, Remote Control (19)

High Voltage Label (22)

CE Aperture Label (24)

CE Certification Label (25)

Figure 2-7: Stabilite 2018 CDRH and Electrical Warning Labels

EC Declaration of Conformity

We,

Spectra-Physics Lasers, Inc.
Scientific and Industrial Systems
1330 Terra Bella Avenue
P.O. Box 7013
Mountain View, CA 94039–7013
United States of America

declare under sole responsibility that the

Stabilite 2018 Argon/Krypton Ion Laser System with a Model 2550 Power Supply and a Model 2670 Remote Control

Manufactured after May 1, 1997,

meet the intent of Directive 89/336/EEC for Electromagnetic Compatibility.

Compliance was demonstrated (Class A) to the following specifications as listed in the official *Journal of the European Communities*:

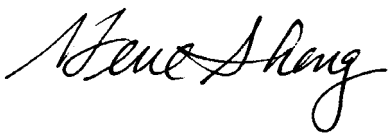
EN 50081-2: 1993 Emissions:

EN 55011 Class A Radiated
EN 55011 Class A Conducted

EN 50082-1: 1992 Immunity:

IEC 801-2 Electrostatic Discharge
IEC 801-3 RF Radiated
IEC 801-4 Fast Transients

I, the undersigned, hereby declare that the equipment specified above conforms to the above Directives and Standards.



Steve Sheng
Vice President and General Manager
Spectra-Physics Lasers, Inc.
Scientific and Industrial Systems
May 1, 1997

EC Declaration of Conformity

We,

Spectra-Physics Lasers, Inc.
Scientific and Industrial Systems
1330 Terra Bella Avenue
P.O. Box 7013
Mountain View, CA 94039–7013
United States of America

declare under sole responsibility that the

Stabilite 2018 Argon/Krypton Ion Laser System with a Model 2550 Power Supply and a Model 2670 Remote Control

Manufactured after May 1, 1997,

meet the intent of Directive 73/23/EEC, the Low Voltage directive."

Compliance was demonstrated to the following specifications as listed in the official *Journal of the European Communities*:

EN 61010-1: 1993 Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use:

EN 60825-1: 1993 Safety for Laser Products.

I, the undersigned, hereby declare that the equipment specified above conforms to the above Directives and Standards.

Steve Sheng
Vice President and General Manager
Spectra-Physics Lasers, Inc.
Scientific and Industrial Systems
May 1, 1997

Sources for Additional Information

The following are some sources for additional information on laser safety standards and safety equipment and training.

Laser Safety Standards

Safe Use of Lasers (Z136.1)
American National Standards Institute (ANSI)
11 West 42nd Street
New York, NY 10036
Tel: (212) 642-4900

A Guide for Control of Laser Hazards
American Conference of Governmental and
Industrial Hygienists (ACGIH)
1330 Kemper Meadow Drive
Cincinnati, OH 45240
Tel: (513) 742-2020

Laser Safety Guide
Laser Institute of America
12424 Research Pkwy., Suite 125
Orlando, FL 32826
Tel: (407) 380-1553

Equipment and Training

Laser Focus World Buyer's Guide
Laser Focus World
Pennwell Publishing
10 Tara Blvd., 5th Floor
Nashua, NH 03062
Tel: (603) 891-0123

Lasers and Optronics Buyer's Guide
Lasers and Optronics
Gordon Publications
301 Gibraltar Dr.
P.O. Box 650
Morris Plains, NJ 07950-0650
Tel: (201) 292-5100

Photonics Spectra Buyer's Guide
Photonics Spectra
Laurin Publications
Berkshire Common
P.O. Box 4949
Pittsfield, MA 01202-4949
Tel: (413) 499-0514

Chapter 3 Controls, Indicators and Connections

System Controls

This chapter describes the use and location of the Stabilite 2018 controls, indicators and connections. It is divided into three sections: the Stabilite 2018 laser head, the Model 2670 Remote Control, and the Model 2550 power supply. Chapter 6 fully describes the optional Model 2680 computer interface that is available for remote computer or terminal control of the Stabilite 2018 system.

The Stabilite 2018 Laser Head

Output End

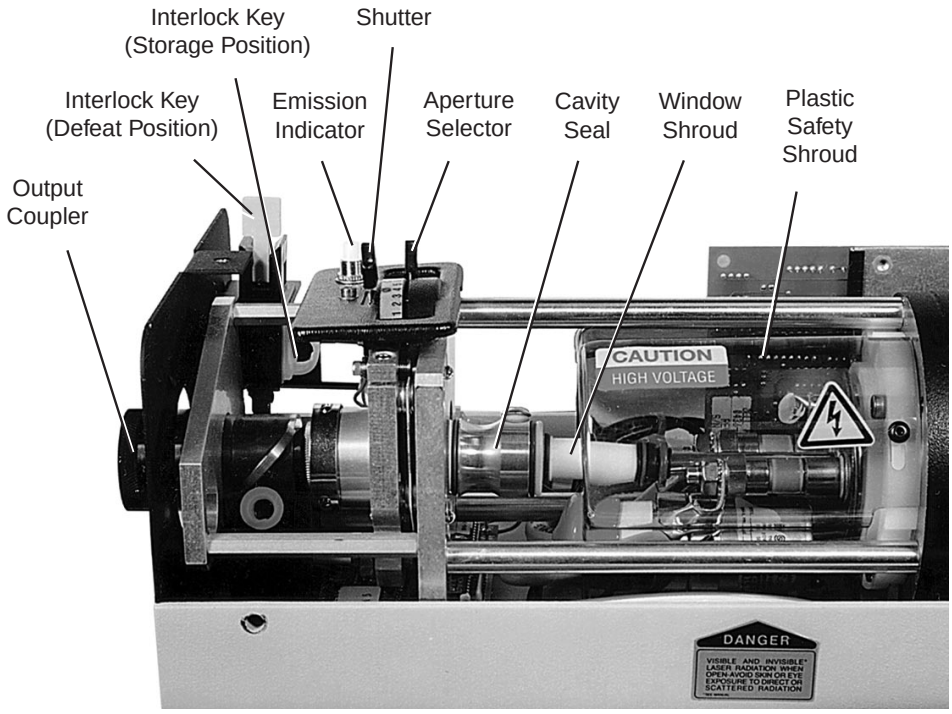


Figure 3-1: Laser Head Interior—Output End

Output coupler—(OC) is one of two intracavity mirrors and it is located at the output end of the laser. Whereas the high reflector at the other end of the laser reflects all light back into the cavity, the output coupler allows part of the intracavity beam to escape as the laser beam. The OC is held in a cup-shaped retainer at the end of a bayonet-type holder (Figure 3-1). Turning the holder counterclockwise 30˚ disengages the holder from the output mirror plate and allows it to be pulled straight out of the laser. To replace the mirror holder, insert it back into the laser and rotate it until it goes all the way in. Then turn it clockwise 30˚ until it clicks into place.

Once the holder is out of the laser, the mirror can be removed by simply pulling it out of the cup. When replacing the mirror, note the small arrow on the barrel which points to the coated surface. The coated side must always face the cavity.

Interlock key—disables the interlock switch (Figure 3-1) to allow the laser to lase when the cover is removed. To disable the switch, place the key in the slot and turn it 90˚ clockwise to lock it in place. To remove it, do just the opposite. When the key is in place, it stands up and prevents the cover from being installed. When not being used, the key is stored in a clip located near the interlock switch.

Emission indicator—glows either when the laser is on, or when it is capable of emitting laser radiation. It is located at the output end of the laser (Figure 3-1),

Shutter—blocks the laser cavity and prevents the laser from lasing. The control lever (Figure 3-1) is located on the laser head near the aperture lever. The shutter is open when the lever is in the "○" position and closed when it is in the "⊘" position.

Apertures—labeled 1 through 10, provide a means to control divergence. Aperture 1 has the smallest diameter, aperture 10 the largest. The setting marked "O" is not an aperture, but is "wide open." Table 3-1 lists the aperture diameters.

Table 3-1: Aperture Diameters

Aperture Number	Diameter mm (in.)
1	1.93 (.076)
2	2.06 (.081)
3	2.16 (.085)
4	2.24 (.088)
5	2.31 (.091)
6	2.39 (.094)
7	2.46 (.097)
8	2.54 (.100)
9	2.64 (.104)
10	2.74 (.108)
O	3.81 (.150)

Cavity seal—together with the dust tube, they seal the cavity between the plasma tube and the mirror plate. The seals (2) can be slid back onto their respective dust tubes to expose the windows for cleaning. An intracavity passive catalyst inside the seal eliminates the build-up of contaminating ozone (O_3) by converting it to molecules of harmless oxygen (O_2). This eliminates the requirement for the typical gas supply, filters, driers, etc.

Control Panel

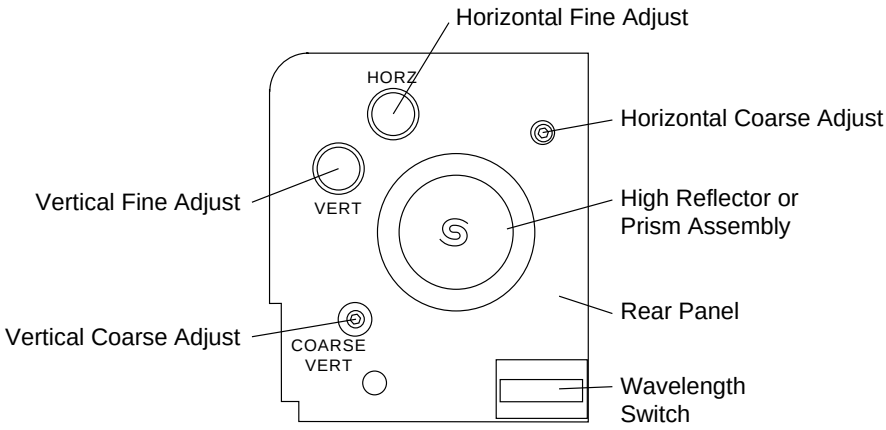


Figure 3-2: Laser Head Control Panel

Vertical fine adjust (VERT)—changes the vertical alignment of the high reflector for fine tuning the optical output for optimum output power. Use the vertical coarse adjust to first tune the laser to the wavelength of choice, then use this control to optimize output.

Vertical coarse adjust (COARSE VERT)—changes the vertical alignment of the high reflector to provide coarse tuning of the optical output over the full range of the laser. Once the laser is tuned to a wavelength, use the fine adjust to optimize laser output. When using the prism, a $^3/_{32}$ in. ball driver is required to adjust the screw that is located just inside the laser head control panel as shown in Figure 3-2.

Horizontal fine adjust (HORZ)—changes the horizontal alignment of the high reflector for fine tuning the optical output for optimum output power.

Horizontal coarse adjust—changes the horizontal alignment of the high reflector to provide coarse tuning of the optical output over the full range of the laser. It is primarily used when doing a vertical search when aligning the laser. Thereafter, only the fine adjust is required. A $^3/_{32}$ in. ball driver is required to adjust the screw that is located just inside the laser head control panel as shown in Figure 3-2.

Note

The vertical and horizontal coarse controls on the output end of the laser are locked at the factory and do not need adjustment. These adjustments are used only to achieve the initial factory alignment after installing the plasma tube.

High Reflector—is one of two intracavity mirrors and it reflects all light back into the cavity. The mirror itself is held in a cup-shaped retainer at the end of a bayonet-type holder (Figure 3-2). Turning the holder counterclockwise 30˚ disengages the holder from the output mirror plate and allows it to be pulled straight out of the laser. To replace the mirror holder, insert it back into the laser and rotate it until it goes all the way in. Then turn it clockwise 30˚ until it clicks into place.

Once out, the mirror can be removed by simply pulling it out of the cup. When replacing the mirror, note the small arrow on the barrel which points to the coated surface. The coated side must always face the cavity.

Prism assembly—replaces the high reflector assembly and adds a prism to the cavity to provide wavelength tuning capability. The prism assembly includes an integral high reflector. The prism disperses the laser beam, bending individual lines according to their wavelength. A line will oscillate if its angle of refraction through the prism matches the vertical rotation angle of the prism. As you adjust the high reflector vertically, the angle at which the beam strikes the prism changes, and with it the wavelength of the oscillating line.

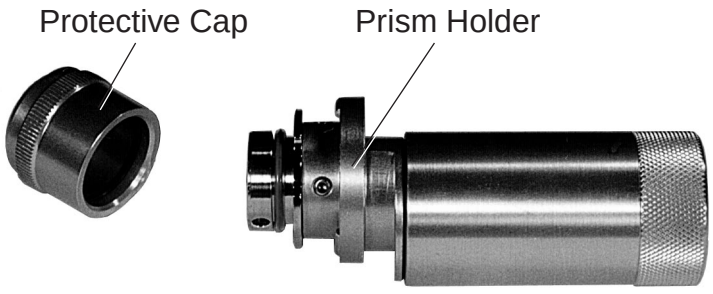


Figure 3-3: Prism

Umbilical cable—provides electrical signals and power to the laser head. Although removable at the power supply, the cable is not removable at the laser head.

Water hoses—provide cooling water to the laser head. The hoses are not removable at the laser head.

Foot Adjustment

The laser head rests on four adjustable feet. The head can be raised or lowered by loosening the threaded clamping ring under the bottom cover and screwing the feet in or out from the inside of the laser using a $^{5}/_{32}$ in. ball driver. The clamping ring is then tightened to lock the foot in place after the height is adjusted.

The Wavelength Selection Switch

WAVELENGTH (nm) switch—calibrates the light pick-off assembly so the power meter remains accurate at different wavelengths. Whenever changing wavelenghts, always set the switch to match the chosen wavelength in nm. Change the setting by pressing the up/down push buttons. The switch is located below the umbilical on the rear panel.

The Model 2670 Remote Control

The Model 2550 power supply is controlled via analog and TTL-level logic signals through the REMOTE connector on the power supply. A description of the pin assignments and signal requirements for the REMOTE connector is provided later in this chapter. The Model 2670 remote control (Figure 3-4) is designed to control and monitor these signals, and it is included as part of your system.

Figure 3-4: The Model 2670 Remote Control

Interlock Status Indicators

If the system shuts off due to an interlock breach, the five INTERLOCK STATUS indicators along the top of the controller identify why the laser has shut off. Generally, the laser shuts off only if a condition exists that could damage the laser or violate CDRH safety regulations.

Resetting the Interlocks

With the exception of an over-current fault, once the fault is corrected, the laser can be restarted by turning off the key switch (which resets the controller and turns off the indicator), then turning it back on. If the OVER CURRENT interlock LED is on, you will need to turn off the main power to the system, then turn it back on to reset this interlock. If the system is controlled via a remote host system through the optional Model 2680 computer interface and the main power is turned off then on, the computer interface must be initialized again before it can be used (refer to Chapter 6, “Optional Model 2680 Computer Interface”).

WATER FLOW indicator—denotes insufficient water flow through the laser head. The laser automatically shuts off to prevent overheating and damage. To correct this problem, increase the water supply to the laser head. Low flow is often caused by a crimp in one of the laser head cooling hoses, or by something sitting on them. Another common problem is a clogged in-line filter (in the facility water supply line) or power supply strainer (located in the water inlet coupling of the power supply).

WATER TEMP indicator—denotes water exiting the laser head exceeds 60°C (140°F). The laser automatically shuts off to prevent overheating and damage. To correct this fault, provide cooler water to the system.

OVER CURRENT indicator—denotes excessive plasma tube current has occurred, shutting off the laser. Look for the cause of the current surge before restarting the laser or damage to the power supply or plasma tube may result. Typically it is due to unstable line voltage when running the laser at high output power.

HEAD COVER indicator—denotes an open laser head interlock switch. Replace the laser head cover or insert the interlock defeat key prior to restarting the laser.

AUX INTLK indicator—denotes an open auxiliary interlock circuit. The connector is on the rear of the Model 2670 remote control. Removing the shorting jumper plug opens the circuit. When the interlock is open, the laser is prevented from starting, or, if opened while the laser is running, it shuts the laser off.

The jumper can be removed and the plug wired to an auxiliary safety device that can shut off the laser in an emergency. For example, the plug can be wired to a normally closed safety switch that is attached to an area access door. When the door is opened, the laser shuts off. Always verify the interlock switch is closed or that the jumper plug is in place prior to restarting the laser.

Fill Status Indicator

When the FILL STATUS indicator is off, the tube plasma level inside the tube (i.e., the quantity of gas) is within the normal operating range. When the indicator is on, the tube plasma level has dropped below normal and a fill is in process. When the indicator is blinking, the plasma level is below normal and a fill has been attempted, but the system cannot fill the tube for some reason. If this ever occurs, immediately turn off the laser and contact your Spectra-Physics Lasers service representative.

Switches and Controls

Key switch—provides limited access to the laser and provides a means to turn on the laser. When set to PLASMA ON, both the emission LED next to the switch and the white light on the laser head turn on to indicate emission is imminent. Laser output will occur in approximately 15 seconds due to the CDRH safety delay.

MODE switch—selects the laser control mode. The CURrent setting maintains constant tube discharge current. This is the mode most often used. The POWER setting maintains constant optical output power.

Power RANGE switch—sets the full scale reading on the remote control meter to 2 W or 10 W when the METER switch (see below) is set to WATTS. If the MODE switch is set to POWER, the output power of the laser adjusts to reflect the meter setting; if set to CURrent, the meter reflects the present laser output power. Note, if the METER switch is changed, from 10 W to 2 W for example, and the previous meter reading was > 2 W, the needle changes to indicate maximum on the 2 W scale (i.e., it will peg the meter).

HEAD SELECT switch—switches power supply output between two laser heads when a second laser head is used. Select A if you have only one head (this is the normal setting). An optional dual head switch box is required in order to use the B setting.

CONTROL switch—selects the control source. When placed in the REMOTE position, the system is controlled either by the Model 2670 remote control or a user-supplied controller attached to the REMOTE connector. When set to the IEEE 488/RS-232 position, the system can be controlled by a computer or terminal through the optional Model 2680 computer interface using either the IEEE 488 parallel input or the RS-232 serial input.

CURRENT control—adjusts the plasma discharge current when the MODE switch is set to CURrent. It has no effect while the MODE switch is set to POWER.

POWER control—adjusts the optical output power when the MODE switch is set to POWER. It has no effect while the MODE switch is set to CURrent.

METER switch—selects one of three meter settings. When set to AMPS, the meter displays the plasma discharge current on the 0 – 50 scale. When set to VOLTS, the meter displays the voltage across the plasma tube on the

0 – 300 scale. And when it is set to WATTS the meter displays the optical output power of the laser on either the 0 – 2 or 0 – 10 W scales, depending on the position of the RANGE switch.

For the 5 minutes following main power turn on, the system must be allowed to warm up before the POWER readings can be considered accurate. This allows the temperature-stabilized photodiode in the power feedback loop to reach operating temperature. This circuit remains stabilized as long as the main power is on. Turning the key switch on or off has no effect.

Rear Panel Connectors

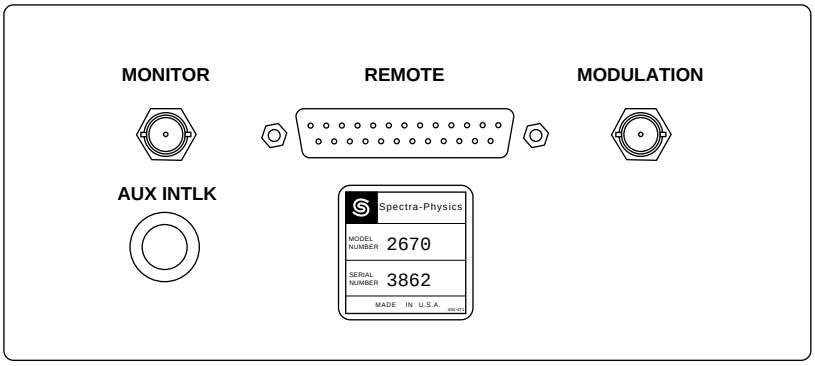


Figure 3-5: Rear panel connections on the Model 2670 remote control.

MONITOR (BNC)—provides a means to remotely monitor the Model 2670 meter reading. It provides 0 to 5 V_{dc} that is proportional to the panel meter reading, depending on the position of the METER and RANGE switches as shown in this table:

METER Switch	Range Switch	0–5 V dc Represents
AMPS	N/A	0 – 50 A
WATTS	2 W	0 – 2 W
WATTS	10 W	0 – 10 W
VOLTS	N/A	0 – 300 V

REMOTE (37-pin D-Sub)—provides connection for the control cable that attaches the Model 2670 to the REMOTE connector on the power supply. Table 3-2 lists the pin assignments and describes the signal requirements in the event a user-supplied remote unit is used.

MODULATION (BNC)—allows laser output to be modulated by a signal applied to this connector. Modulation specifications are listed in the chart below.

Category	Specifications
Input Impedance	20 kΩ
Input Voltage Range	± 5 V
Modulation Sensitivity:	
Current mode	10 A tube current/volt
Light mode (10 W)	2.0 W optical output power/volt
Light mode (2 W)	0.4 W optical output power/volt

The control signal is the sum of the signals from the MODULATION connector and the active CURRENT or POWER control knob. To illustrate, with the system in current mode and the CURRENT control set so the meter reads 25 A, a ± 1 V signal applied to the MODULATION connector modulates the plasma tube current ± 10 A; that is, it varies the current from 15 A to 35 A.

AUX INTLK (2-pin)—provides attachment for an external interlock, such as a normally closed switch that is wired to an area access door or to some other auxiliary safety equipment. When opened, the door or safety device turns off the laser. These two contacts must be shorted together in order for the laser to operate. A simple jumper is installed in the plug that is provided with your system. The plug can be rewired for use with an external interlock.

The Model 2550 Power Supply

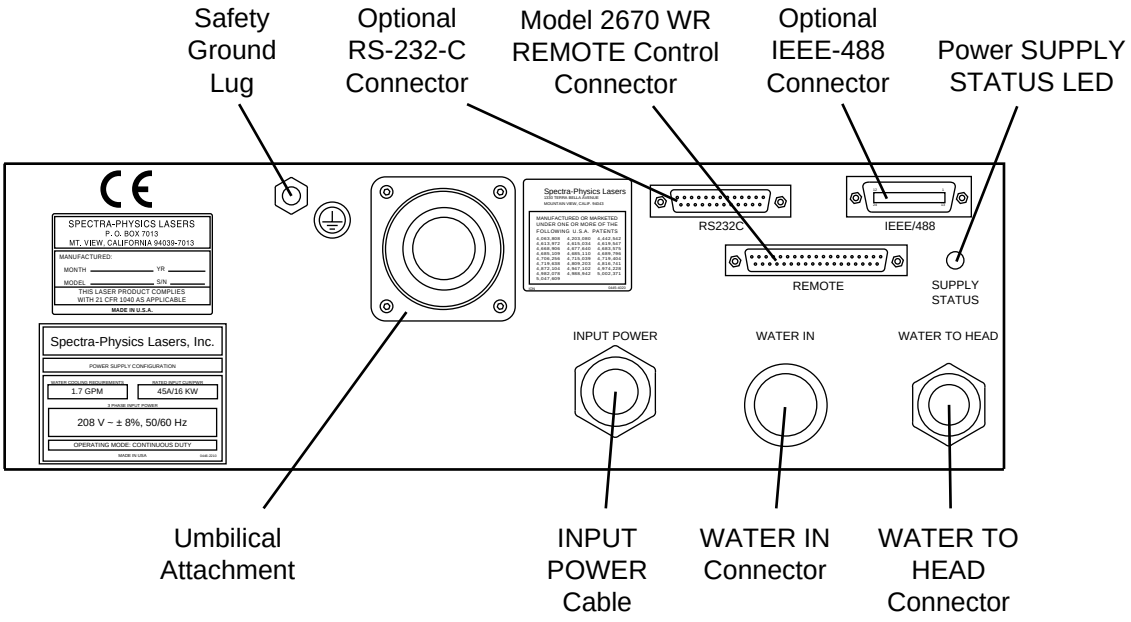


Figure 3-6: Power supply control panel

The power supply provides power conversion from 208 Vac line voltage to the dc supplies required by the laser. It also provides control logic and safety interlocks for operating the system, as well as interfaces for user control. Your system may or may not contain the optional Model 2680 computer interface which is described in Chapter 6.

Umbilical cable—provides connection for the laser head umbilical cable. To detach the cable from the power supply, disconnect the medium current harness at J_1 on the power pc board (the board with the small fuses), the control cable from J_2 on the control pc board (the board in the tray), and the ground cable from the lug on the back panel. Next, remove the four Allen screws from the umbilical hub and remove the umbilical. The umbilical is permanently attached to the laser head.

Optional RS-232-C serial connection—provides a serial connection for a computer or terminal for remote control of the system. Refer to Chapter 6, "Optional Model 2680 Computer Interface," for more information.

Optional IEEE-488 parallel connection—provides a parallel connection for a computer or terminal for remote control of the system. Refer to Chapter 6, "Optional Model 2680 Computer Interface," for more information.

REMOTE connector—provides connection for either the standard Model 2470 remote control or for a remote unit provided by the user. See Table 3-2 earlier in this chapter for pin descriptions and assignments.

Power SUPPLY STATUS indicator—glows to indicate the 5 V_{dc} power supply is working properly. It must be glowing before the laser will start.

Power Supply REMOTE Interface Pin Assignments

Table 3-2 on the following pages describes the function of each pin in the REMOTE interface connector. All logic inputs are optically coupled and require driving logic that can sink 10 mA with a "logic TTL low" voltage of less than 0.8 V.

Table 3-2: Remote Interface Pin Assignments

Pin	Name	Type	Description
1	GND	Common	Model 2550 power supply digital ground
2	GND	Common	Model 2550 power supply digital ground
3	Computer/Remote	Input	Selects control source. When this input is pulled low, control signals on input pins 4, 5, 6, 7 and 8 are enabled. When the input is inactive (high), signals on pins 4, 5, 6, 7 and 8 are ignored, and control inputs are taken from a computer connected through the Model 2180 computer interface.
4	Head Select	Input	Either one of two laser heads may be selected. Inactive = head A, pulled low = head B.
5	Power Range Select	Input	Selects power range. Inactive or high = 2 W, pulled low = 10 W.
6	Control	Input	Selects feedback mode. Inactive or high = current mode, pulled low = power mode.
7	Not Connected		
8	Plasma On/Off	Input	The main on/off switch. Pulling this input low closes the power contactor and begins warming the tube cathode. The laser will light after approximately 15 sec.
9	Auxiliary Interlock Open	Output	If the interlock is open, the output is inactive (high); if it is closed, the output is pulled low.
10	High Water Temp	Output	If the head outlet water temperature exceeds 60°C (140°F), the output is inactive (high); otherwise, the output is pulled low.
11	Head Cover Interlock	Output	If the head cover is removed, the output is inactive (high); otherwise, output is pulled low.
12	Low Water Flow	Output	If the cooling water falls below 1.8 US gal/min, the output is inactive (high); otherwise, the output is pulled low.
13	Over Current Fault	Output	Inactive (high) indicates over current; pulled low indicates no fault.
14	Tube Voltage Monitor	Output	0 to 5 V represents 0 to 300 V.
15	Tube Current Monitor	Output	0 to 5 V represents 0 to 50 V.
16	Power Monitor	Output	0 to 5 V represents 0 to 2 W in the low power range or 0 to 10 W in the high power range.
17	Buffered +5 V Reference	Output	5 V reference (10 mA maximum)

Table 3-2: Remote Interface Pin Assignments *(cont.)*

Pin	Name	Type	Description
18	Modulation Set Point	Input	Command signal (0 to 5 V, full scale) that modulates both the current control input (pin 19) and the power control input (pin 36). (See MODULATION connector description).
19	Current Control Set Point	Input	Command signal (0 to 5 V, full scale) that selects the desired tube current with the laser in current mode (pin 6 inactive). May manually select the current set point when it is connected to the wiper arm of a 10 kΩ pot. Connect the other two terminals of the pot across pins 17 (buffered +5 V REF) and 37 (control common). The input selects from 0 to 50 A of tube current at 10 A/V. Inputs exceeding minimum and maximum current limits of the power supply will be clipped.
20	Not Connected		
21	Not Connected		
22	Digital Input Common	Input	Current source for optically coupled logic inputs. Requires +5 V pull-up at 50 mA, which may be user supplied or taken from pin 27.
23	Auxiliary Interlock	Input	One side of the interlock input. Must be jumpered with pin 24 for normal use (the interlock requires a floating contact to make or break the interlock).[1]
24	Auxiliary Interlock Return	Input	Common interlock input. Must be jumpered with pin 23 and with pin 25 for normal use.[1]
25	Key Interlock	Input	One side of the interlock input. Must be jumpered with pin 24 for normal use.[1]
26	Key Interlock Open	Output	If key interlock is open, the output is inactive (high), otherwise, the output is pulled low.
27	+5 V	Output	+5 V at 500 mA (max) for customer use
28	+12 V	Output	+12 V at 50 mA (max) for customer use
29	–12 V	Output	–12 V at 50 mA (max) for customer use
30	Tube Fill Status	Output	If the automatic gas fill circuit is filling the plasma tube, the output is inactive (high). If the tube cannot be filled because the gas reservoir is empty, the output is repeatedly pulled low and high (1 Hz square wave). When the output is held constantly low it indicates that the plasma tube is maintaining sufficient gas pressure.
31	Remote Emission Indicator	Output	If the laser is turned off, the output is inactive (high); otherwise, output is pulled low.
32	Not Connected		
33	Current Monitor Return	Output	Return for pin 15, 0 to 5 V current monitor output.

[1] *The laser is turned off automatically when this or any other system interlock is open (an open system interlock is indicated when pin 9, 10, 11, 12 or 13 of the REMOTE interface connector is inactive). Once an open interlock has caused the laser to turn off, the laser will remain off even after the interlock is closed again. The laser may be restarted by:*

a. opening the key interlock (removing the jumper between pins 24 and 25) for 15 sec, then closing it again; or

b. turning off and on the circuit breaker in the main power line.

Table 3-2: Remote Interface Pin Assignments *(cont.)*

Pin	Name	Type	Description
34	Power Monitor Return	Output	Return for pin 16, 0 to 5 V power monitor output.
35	Volt/REF Monitor Return	Output	Return for pin 17, (buffered +5 V reference output) and pin 4 (voltage monitor output).
36	Power Control Set Point	Input	Command signal (0 to 5 V, full scale) that selects the optical output power when the laser is operated in the power mode (pin 6 low). May be used to manually select the power set point when it is connected to the wiper arm of a 10 kΩ potentiometer. Connect the other two terminals of the pot across the pins 17 (buffered +5 V REF) and 37 (control common). a. When the 10 W power range is selected (pin 5 pulled low), the input selects from 0 to 10 W at 2 W/V. b. When the 2 W power range is selected (pin 5 inactive), the input selects from 0 to 2 W at 0.4 W/V. Inputs exceeding the minimum and maximum current limits of the power supply will be clipped.
37	Control Common	Input	Return for set point inputs: pin 18 (modulation), pin 19 (current control) and pin 36 (power control).

Chapter 4 Installation

The Stabilite® 2018 laser system is extremely easy to install. Simply place the laser head, power supply and controller near each other, then plug the laser head umbilical into the back of the power supply (2 connections), plug the controller into the back of the power supply, and hook up the two cooling hoses.

Note

The following installation procedures are not intended as guides to the initial installation and set-up of your laser. Customer training is available through the Spectra-Physics Lasers service department. If you wish a Spectra-Physics Lasers service representative set up the laser at your site, please call to arrange an installation appointment. Allow only qualified personnel to install and set up your laser. Any damage that occurs during a user-performed installation is not covered under warranty.

Placement of the Laser Head, Power Supply and Remote Control

The only tools you will need to set up your system on a daily basis are a $^{5}/_{32}$ ball driver (to adjust beam height) and hemostats and lens tissue (to clean the optics). These tools are provided in your accessory kit.

1. Place the Stabilite 2018 laser head on the laser table and position the head so it is roughly aligned to the target system.
2. Place the Model 2550 power supply within 2 meters of the laser head: close enough so its umbilical and hoses can be attached to the power supply control panel, but far enough away so the power supply is out of the way.
3. Finally, place the Model 2670 remote control (if used) nearby in a location that is accessible during normal operation.

Connecting the Laser Head Umbilical to the Power Supply

Two cables in a protective flexible hose comprise the umbilical that connects the laser head to the power supply. The umbilical is permanently attached to the laser head but is attached to the power supply via two connectors (plus two hoses). Figure 4-1 shows the power supply control panel.

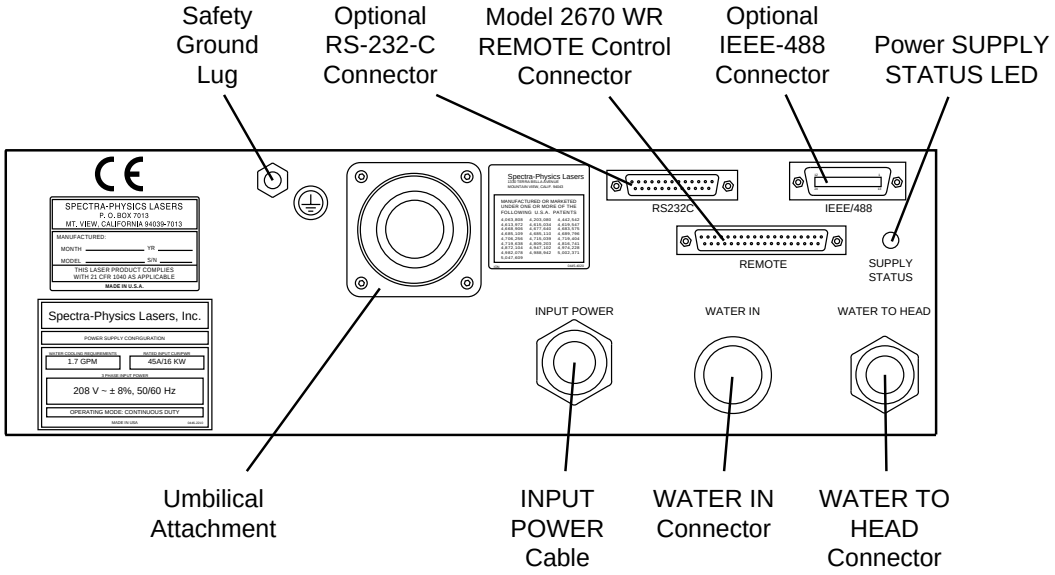


Figure 4-1: The Model 2550 Power Supply Control Panel

To attach the umbilical to the power supply, connect the large and small plugs of the umbilical to their respective connectors on the power supply control panel.

1. Insert the smaller plug into the lower connector and rotate the main core until its keys line up with those in the connector and the plug begins to make the connection. Next, twist the outer shell clockwise about $^1/_2$ turn to complete the connection and to lock the plug in place.
2. Insert the larger plug into the upper connector and rotate the main core until its key slot aligns with the tab at the top of the connector. Then push the plug in so that it begins to make the connection. As you do this, screw the outer shell clockwise. This pulls the plug into place to complete the connection and locks the plug in place.

Disconnecting the Laser Head Umbilical from the Power Supply

To detach the umbilical from the power supply, simply disconnect the large and small umbilical plugs. Turn both plug shells counterclockwise while pulling on the connector. You may have to wiggle them a bit to disengage them.

Connecting to the Water Supply

Cooling Water Requirements

Cooling water may be supplied from an open-loop system with the heated water directed to a drain. Refer to Table 4-1 for flow, pressure, and thermal ratings, and requirements for water quality. The diameter of the incoming water service line should be at least $^{5}/_{8}$ in. All hose connections are U.S. garden hose variety.

Table 4-1: Stabilite 2018 Cooling Water Requirements

Flow Rate (min)	6.4 l/min (1.7 gal/min)
Inlet Temperature	10 – 35°C (50 – 95°F)
Differential Pressure (min)[1]	138 kPa (20 psig)
Inlet Pressure (max)	690 kPa (100 psig)
Hardness (max)	< 100 ppm calcium
pH Level	7.0 to 8.5
Particulate Size (max)[2]	< 200 μ dia.
Heat Load	16 kW (910 Btu/min)

Warning!

Verify the cooling water enters the power supply first, before going to the laser head. If the supply line is connected incorrectly, significant damage can occur. Such damage is not covered by your warranty. Figure 4-2 shows a properly connected system.

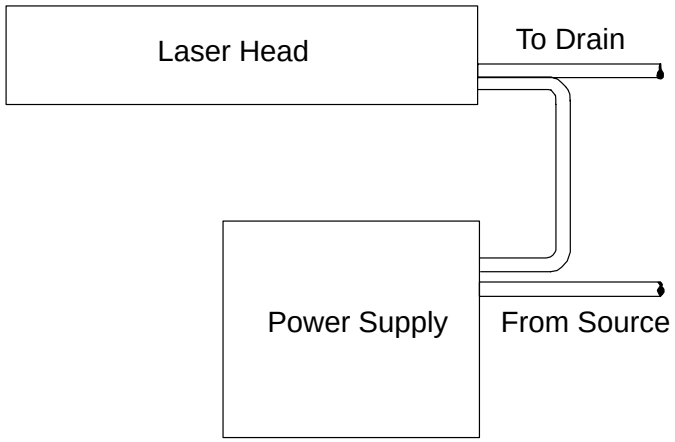


Figure 4-2: Connecting the Cooling Water Loop

[1] *Defined as the difference between the exit back pressure and the input pressure.*

[2] *A 25 μ filter is provided with the laser.*

1. Install the water filter that is supplied with the laser into the supply line. It has $^3/_4$ in. NPT pipe threads.

   Observe the direction of the flow arrow marked on the filter case. To insert a 25 µ filter cartridge (supplied), unscrew the lower housing, place the cartridge over the hub in the bottom of the housing, then screw the housing back onto the fixture.

2. It is highly recommended that a pressure regulator be included in the installation and that it be set for the rated pressure found in Table 4-1.

3. Connect the cooling water supply line to the female fitting on the power supply.

4. Connect the male fitting on the power supply to the female fitting on the laser head.

5. Connect the male fitting on the laser head to the water return line.

Closed-loop Cooling Systems

Because local water supplies vary in pressure and temperature throughout the day, or can have a high calcium content (hard water), a closed-loop cooling system such as the Model 315A heat exchanger/water conditioner may be used to regulate the pressure, temperature, and flow rate of the cooling water. This will enhance the stability of the laser and improve its performance. Its specifications must meet or exceed the Stabilite 2018 cooling requirements listed in Table 4-1.

Control Connections

The Model 2670 remote control, which is supplied with the system, is typically used to operate the Stabilite 2018 system. However, the system can also be controlled using the optional Model 2680 computer interface or a user-supplied unit. If the Model 2680 was ordered at the time of purchase, it will already be installed.

Installing the Model 2670 Remote Control

1. Attach the cable from the Model 2670 remote control to the connector marked REMOTE on the control panel of the Model 2550 power supply.

   This cable terminates in a polarized, 37-pin D-sub connector; it can only go in one way. Push it in until it seats, then tighten the 2 screws to keep the cable from pulling loose during use.

2. Place the remote control on the laser table so that it is easily accessed.

3. If a safety switch is to be used, attach it to the auxiliary interlock (AUX INTLK) connector on the back of the remote control.

If a door switch is to be used as part of the laser interlock system for example, remove the jumper plug from the AUX INTLK connector, and replace it with a plug that is wired to the safety switch. The supplied jumper plug may be modified for this purpose by removing the shorting wire inside. The switch must be wired so that it is normally closed during laser operation. Opening the switch will turn off the laser.

If no safety switch is used, verify the unmodified jumper plug is secure in the AUX INTLK connector. The system will not start without it.

4. Refer to Chapter 3, "Controls, Indicators and Connections," for descriptions of the controls and functions of the Model 2670 remote control. Refer to Chapter 5, "Operation," for information on how to use it to operate the laser system.

Installing the Computer Interface Cable

A computer or terminal may be optionally connected to either the RS-232 serial interface or the IEEE 488 parallel interface on the power supply connector panel when the optional Model 2680 computer interface (CI) is installed. Refer to your computer manual for information on the type of interface(s) is has available.

RS-232-C Interface

1. Connect the computer to the laser system.

   Connect a serial cable between the RS-232-C connector on the the power supply and the mating connector on the back of the computer or terminal.

   IBM-PCs and compatibles use a polarized 25- or 9-pin connector with **pins** (not sockets) for serial ports. The other 25-pin connector with **sockets** is a modified Centronics parallel printer port. *Do not connect to this port*. Refer to Chapter 6, "Optional Model 2680 Computer Interface: RS-232-C Interface, Operation," for a description of the RS-232-C serial interface and how it is used. NO TAG in that same section shows the connector pinout for both the IBM-PC 25-pin and IBM-PC AT 9-pin connectors. Use this as a guide for wiring your connecting cable.

   Manufacturers of terminals use various types of connectors for an RS-232-C interface. Some use pins, others use sockets. Most do not use 25 wires even if a 25-pin connector is used. Refer to your terminal manual for information on which port should be connected to the Model 2550.

2. Push each connector in until it seats, then tighten the 2 screws to keep the cable from pulling loose.

3. Refer to Chapter 6, "Optional Model 2680 Computer Interface: RS-232-C Interface," for information on how to set the CI dip switches for baud rate, parity, etc.

IEEE 488 Interface

Many computers from Hewlett-Packard and others, and engineering test and measurement equipment from vendors such as Hewlett-Packard, Keithly and Fluke incorporate the IEEE-488 parallel bus into their products so that the computers can be used as automated controllers to operate the test equipment, thus making the job of running and monitoring otherwise tedious tests easier for the manufacturing or test engineer. Because of its popularity, this bus is provided as an alternative control interface on the optional Model 2680.

The IEEE-488 connector has 24 pins and a polarized shell with metric fasteners. Up to 32 IEEE 488–compatible devices can be daisy-chained together in either a serial or star network, with one master controller and various "talkers" and "listeners" for drivers, monitors, and measuring devices. Refer to Chapter 6, "Optional Model 2680 Computer Interface: IEEE-488 Interface," for a description of the interface and the CI commands, information on how to set the dip switches on the CI, and information on programming. Refer to your computer manual or your third party IEEE-488 controller manual for information on how to use their IEEE-488 interface product.

1. Connect the IEEE-488 parallel cable (supplied by your computer or controller vendor) between the IEEE-488 connector on the the power supply and the IEEE-488 connector on the back of your computer, terminal, or controller.

   Unlike the RS-232-C interface, the IEEE-488 cable is standardized: there are no wires to modify. Simply buy a cable from your IEEE-488 vendor and plug it in.

2. Push each connector in until it seats, then tighten the 2 screws on each connector to keep the cable from pulling loose.

   Note that the screws are metric and will not screw into a similar, but non-IEEE 488-compatible connector.

Using a User-supplied Control Device

If a user-supplied controller is to be used, connect it to the Model 2550 power supply in the same manner as the Model 2670 remote control (see "Installing the Model 2670 Remote Control" earlier in this chapter). Specifications for the REMOTE connector signals are given in Table 3-2 in Chapter 3. CDRH requirements for a user-supplied controller are listed in Chapter 2, "Laser Safety: CDRH Requirements for a Custom Remote Control or for Operation with the Optional Model 2680 Computer Interface."

Laser Head Inspection

Great care was taken in preparing your laser for shipping. However, it is prudent to check out your unit before it is used the first time. To do this, remove the laser head cover and inspect the interior.

1. Inspect the cavity seal on each end of the plasma tube. If the seal was dislodged during shipping, the plasma tube window will have to be cleaned; refer to Chapter 7, "Maintenance: Cleaning the Plasma Tube Windows," for details.
2. Inspect the shutter and aperture. Both should operate easily, and the shutter should open fully. "◯" on the aperture lever is the open position.

Adjusting the Height of the Laser Head

The laser head rests on four adjustable feet. The head can be raised or lowered by loosening the threaded retaining ring under the lower cover and screwing the feet in or out. After the feet are adjusted, tighten the clamping rings up against the cover. When done, the feet should all be the same height and be within 0.3 cm ($^1/_8$ in.) of one another.

Pre-operation Water Leak Tests

Perform the following test before you start your laser for the first time. It is your final assurance that the system arrived in proper working condition.

1. Remove the cover to the laser head (4) and power supply (14).
2. Slowly open the water supply valve until you hear the water begin to flow.
3. Check for leaks at all plumbing connections within the laser head, and at the ends of all water hoses.
4. Look for water inside and under the power supply.
5. If there are no leaks, open the valve and apply full pressure up to the rating specified in Table 4-1.
6. If leaks are present, check all water seals for proper seating. If leaks persist, shut off the water supply, drain the cooling system, and call your Spectra-Physics Lasers representative.
7. When you are satisfied there are no leaks, install the laser head and power supply covers. Verify that the each cover actuates the cover interlock switch located near the umbilical entry.

Connecting to Electrical Service

The power supply requires three-phase, 208 V (±8%), 45 A electrical service.

Connect the green lead of the power cable to *earth ground*, not neutral. Connect the remaining three leads to the legs of the three-phase service; sequence is not important. A circuit breaker or wall switch should be placed between the electrical service and the power supply; the breaker or switch must be rated for at least 50 A.

Warning!

Do not exceed 208 V (±8%). If the service does not fall within this range, use a transformer to bring it to within this range. Contact your Spectra-Physics Lasers service representative for details.

A grounding lug is provided on the power supply control panel for the attachment of a second ground cable (see Figure 4-1). This attachment point is typically used when the laser system is incorporated into a larger system where a single-point common ground is required.

Setting the Wavelength Selection Switch

Verify the wavelength selection switch is properly set (in nm) for the actual wavelength to be used. This ensures the power meter is accurate.

Chapter 5 Operation

The Stabilite® 2018 laser can be operated using one of the following control methods:

- The Model 2670 remote control, which is provided with the system, and is connected to the Model 2550 power supply REMOTE connector.
- A computer or terminal that is connected to the optional Model 2680 computer interface using either either the IEEE 488 or RS-232 interface.
- A user-supplied controller that is connected to the power supply REMOTE connector.

Warning!

Spectra-Physics Lasers recommends using the Model 2670 remote control or the optional Model 2680 computer interface for controlling the Stabilite 2018. Repair for power supply damage resulting from the use of any other controller is not covered under the warranty.

Laser Start-up

This section describes the start-up sequence using the Model 2670 remote control. This procedure is also typical of operation when using a custom control device connected to the REMOTE interface, or when using a terminal or computer connected to either the IEEE 488 or RS-232-C connectors of the Model 2550 power supply.

The output beam of this laser is a safety and fire hazard. Avoid directly viewing the beam or its reflections. Avoid blocking it with clothing or parts of the body.

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1. Place a folded metal target (see Chapter 2, “Laser Safety”) or a power meter in the beam path, and close the shutter.
2. Check the power line voltage.

   It should be 208 Vac nominal (between 188 and 228 Vac). Extended operation near the range limits is not recommended.

3. Verify that the green/yellow lead of the power cable is connected to *earth ground*, not neutral, and that, when required, a grounding cable is connected to the ground lug on the power supply control panel.
4. Turn on the cooling water.
5. Set the remote control module for the desired turn-on conditions:
   - MODE—current
   - CONTROL—REMOTE or IEEE 488/RS-232
   - CURRENT level to minimum
   - Key switch off
6. Turn on the main power.
7. Turn on the key switch.

   The PLASMA ON indicator will glow and emission will start about 15 seconds later.
8. Open the shutter.

Adjusting for Maximum Output Power

Misalignment of the high reflector is the most frequent cause of low output power. The mirror must be perpendicular to the beam for optimum performance. The mirror plate is designed so the horizontal and vertical planes can be independently adjusted.

8. Increase output power to a suitable level for monitoring.
9. Monitor the optical output power as you adjust the high reflector for maximum optical output.
   a. Achieve maximum power with one control before using the other. The adjustments may interact, so repeat the procedure, first with one control, then with the other, until maximum output power is achieved.
   b. If the unit stops lasing while you are turning one of the controls, turn it in the opposite direction until lasing is restored. Work only with that control until you get the unit lasing again. If you cannot restore lasing, refer to Chapter 8, “Service and Repair: Vertical Search Alignment Procedure.”
   c. Adjust only the high reflector to achieve maximum power. The curved output coupler should remain stationary under normal operating conditions. If its alignment is disturbed, realignment may be time consuming and tedious. If, after adjusting the high reflector, the output remains below specification, clean the mirrors and plasma tube windows; refer to Chapter 7, “Maintenance: Cleaning Optics.”
10. Set the MODE switch for power control and adjust output power to the desired level.

This completes the laser start-up procedure.

Automatic Fill Circuit

After laser emission, the automatic fill circuit has a 30 min delay period when no filling is permitted. This allows the gas to warm up and stabilize. After this delay period, the fill system will fill the plasma tube with gas when required.

The remote control FILL STATUS indicator glows whenever the fill sequence is in process. If the fill circuit cannot fill the tube (it is either out of gas or there is an electro/mechanical malfunction), the FILL STATUS indicator will blink at a 1 Hz rate. If this occurs, immediately turn off the laser and call your Spectra-Physics Lasers service representative.

Removing and Installing Mirror Holders

Bayonet-style Mirror Holders

The output coupler and high reflector use similar holders. Both are designed with a bayonet locking mechanism and incorporate a three-ball optical seating. Changing optics is easy, with repeatable results. Very little, if any, adjustment of the high reflector is necessary when changing optics.

Interchanging Mirrors

Warning!

Optics are fragile and can be damaged if dropped. Work over a clean, dust-free, soft surface.

The Stabilite 2018 comes equipped with a set of mirrors designed for optimum performance within the wavelength range specified at the time of purchase.

Be sure the laser is warmed up and stable before proceeding.

1. Adjust the high reflector vertically and horizontally for maximum broadband power.
2. Remove the broadband mirror holder.

   Turn the mirror holder counterclockwise to snap it out of lock. Turn it another 30° and pull it straight out of the mirror plate.

Caution!

Do not leave the optical cavity of the laser open for extend periods of time. Doing so shortens the life of the intracavity passive catalyst, which absorbs intracavity O_3 (which contaminates the windows).

3. Remove and replace the mirror.

   The mirror holders use a spring-loaded cup to hold the optic. Using clean, lint-free finger cots or powder-free latex gloves, **hold onto the cup** and pull the optic out by its edges. It fits snugly into the cup but will slide out easily.

Warning!

Do not hold onto the holder assembly as you remove the optic—you can damage the spring.

Place the mirror in its protective case. A Spectra-Physics Lasers part number and an arrow appear on the edge of each mirror. The arrow points to the coated side. Insert a new mirror into the holder so the arrow points into the laser cavity.

4. Install the mirror holder.
5. Adjust the high reflector vertically and horizontally for maximum power.

Interchanging the Broadband High Reflector and Prism Assembly

Warning!

Optics are fragile and can be damaged if dropped. Work over a clean, dust-free, soft surface.

Be sure the laser is warmed up and stable before proceeding.

To change from a broadband mirror to the prism assembly:

1. Adjust the high reflector vertically and horizontally for maximum broadband power.
2. Remove the broadband high reflector holder.

   Keep the mirror covered or place it in its container when it is not being used to protect it from dust and contamination.
3. Install the prism assembly.

   Remove the protective cap from the prism assembly, then install it just like a standard mirror assembly.
4. Adjust the prism vertically and horizontally for maximum power.

   Because the broadband high reflector was optimized perpendicular to the beam, the prism assembly should lase at the factory-set interchange wavelength of 647.1 nm.

To change from the prism assembly to the broadband mirror:

1. Adjust the prism vertically and horizontally for maximum power at the interchange wavelength of 647 nm.
2. Remove the prism and replace its protective cap.
3. Install the broadband mirror.

Wavelength Selection Using a Prism

The prism assembly contains both a prism and a flat high reflector. The prism disperses the laser beam, bending individual lines according to their wavelength. A line will oscillate if its angle of refraction through the prism matches the vertical rotation angle of the prism. As you adjust the prism vertically, the angle at which the beam strikes the prism changes, and with it the wavelength of the oscillating line.

When changing from one wavelength to another, remember to set the WAVELENGTH (nm) switch on the laser head rear panel accordingly.

Setting the Aperture for TEM_{00} Output

Well defined variations in the spatial distribution of the electromagnetic field perpendicular to the direction of travel of the beam are called transverse electromagnetic (TEM) modes. These variations determine, in part, the power distribution across the beam.

Many laser applications require a TEM_{00} beam, which appears as a round spot that is brighter in the center than it is on its edges (Figure 5-1). Other modes have different irradiance contours and are identified by the number of nulls in the irradiance distribution. The mode pattern for a given laser is a function of wavelength and can be affected by the size of the aperture, scratches on the mirrors, or dust on the optical surfaces.

The Stabilite 2018 employs a lever-operated aperture plate containing 10 aperture sizes, labeled 1 through 10, which allows you to tune to TEM_{00}. Aperture 1 has the smallest diameter, aperture 10 the largest. The setting marked “O” is not an aperture, but is “wide open.” Typically, an aperture setting from 5 to 8 will produce TEM_{00} output at 514.5 nm; a setting from 2 to 6 will produce TEM_{00} output at 488.0 nm. Table 5-1 lists the actual aperture diameters.

The Stabilite 2018 is shipped with the broadband high reflector installed. To get a TEM_{00} output at a single line, you must install the prism assembly and select the proper aperture. Refer to “Removing and Installing Mirror Holders” above for instructions on changing optics.

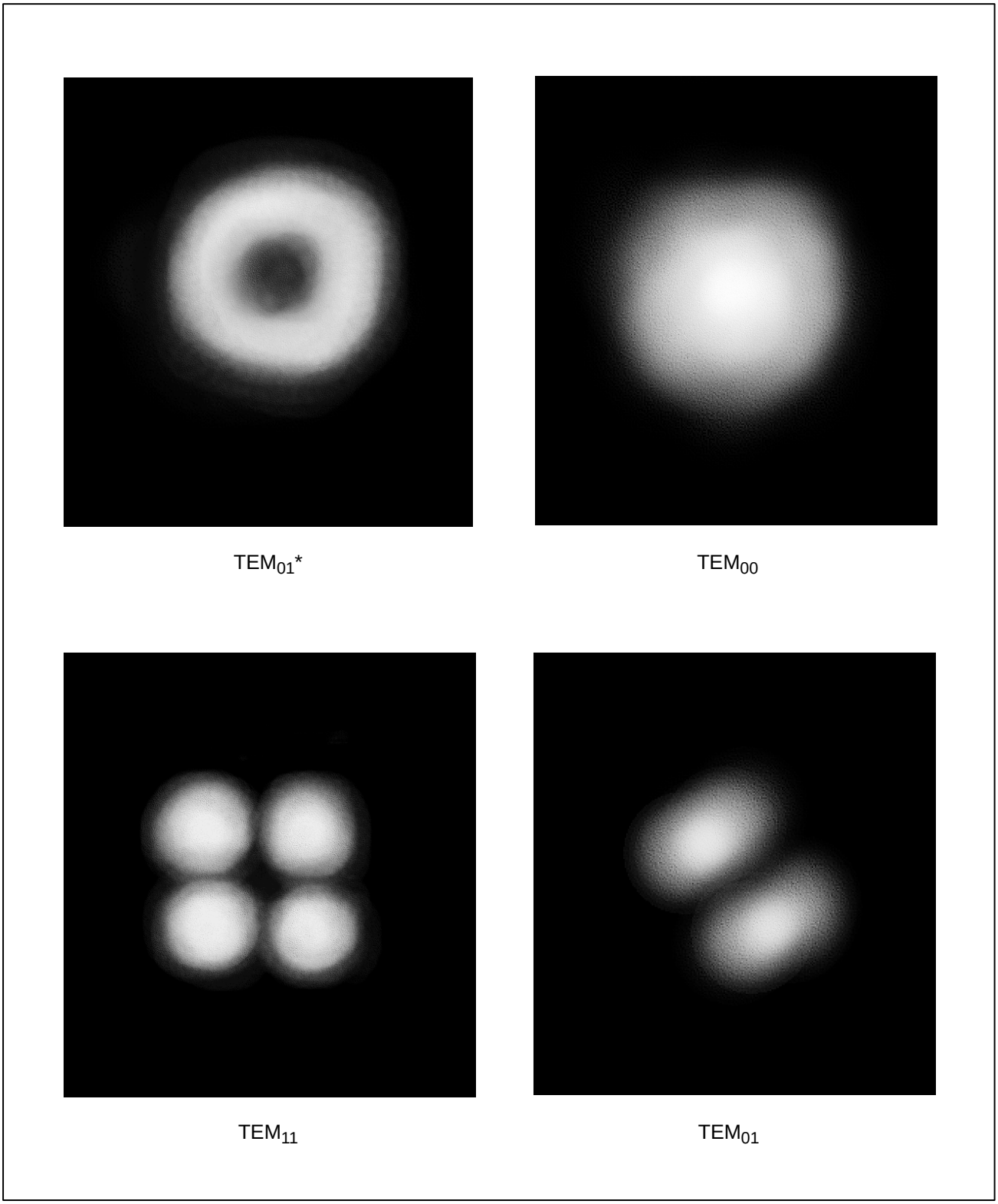


Figure 5-1: Transverse Modes

Table 5-1: Aperture Diameters

Aperture Number	Diameter mm (in.)
1	1.93 (.076)
2	2.06 (.081)
3	2.16 (.085)
4	2.24 (.088)
5	2.31 (.091)
6	2.39 (.094)
7	2.46 (.097)
8	2.54 (.100)
9	2.64 (.104)
10	2.74 (.108)
O	3.81 (.150)

Viewing the Mode

You may find it difficult to identify the mode of a beam by direct observation; however, lenses can be used to expand the beam, making observation of irradiance distribution easier.

The Stabilite 2018 is a Class IV laser; therefore the beam, whether direct or reflected, is a safety hazard. Use a neutral density attenuator for mode observations and adjustments, and make sure the beam only strikes low-reflectance surfaces.

Place a positive lens (focal length of about 1.5 cm) in the beam path and observe the beam, expanded to about 0.5 m, on a wall or screen. Multimode conditions appear as complex variations in the pattern. As the diameter of the aperture is reduced, the multimode patterns will shrink in overall diameter, and the rapid intensity variations across the beam will disappear. TEM_{00} output should occur with one of the available aperture sizes.

Shutdown Procedure

1. Turn off the key switch and remove the key.

   If system start-up is controlled by a password on a computer, log out to the point that a password would be required to once again start the laser. If a key floppy or tape is used, remove the floppy or tape from the computer. Do not leave the laser accessible to people who are untrained in laser safety or operation.

2. To allow accumulated heat in the plasma tube to dissipate into the circulating cooling water, wait about 2 minutes after plasma current has been turned off before turning off the water supply.

Turning the water off abruptly will cause the water in the jacket around the tube to become over-heated and vapor pockets to form, resulting in a non-even cooling of the tube.

3. Open the main circuit breaker.

This completes the shutdown procedure.

Chapter 6 Optional Model 2680 Computer Interface (CI)

The Stabilite® 2018 laser can be operated using one of the following control methods:

- The Model 2670 remote control that is provided with the system. It is connected to the Model 2550 power supply REMOTE connector.
- A computer or terminal that is connected to the optional Model 2680 computer interface using either either the IEEE 488 or RS-232 interface.
- A user-supplied controller that is connected to the power supply REMOTE connector.

Warning!

Spectra-Physics Lasers recommends the use of the Model 2670 remote control or the optional Model 2680 computer interface for controlling the Stabilite 2018. Repair for power supply damage resulting from the use of any other controller is not covered under warranty.

This section describes the optional Model 2680 computer interface (CI). The CI allows the laser system to be run from a computer or terminal via an RS-232-C serial or IEEE 488 parallel interface. Figure 6-1 shows the location of the two interface connectors on the power supply. The CI can be ordered with the system, or separately at a later date. To order, call your Spectra-Physics Lasers representative and request a "Model 2680 computer interface for the Model 2550 power supply."

Description

The CI contains the hardware and firmware to translate commands sent via the IEEE 488 or RS-232-C interface into system signals, and vice versa. Typically, the remote control remains in the control loop as part of the system and the computer is selected through it by setting the CONTROL switch to the IEEE 488/RS-232 position. However, if the computer is to control the system directly without the Model 2670 remote control in the loop, the remote jumper plug (included with the CI) must be attached to the REMOTE connector on the power supply in lieu of the Model 2670.

Refer to Chapter 2, “Laser Safety: CDRH Requirements for a Custom Remote Control or for Operation with the Optional Model 2680 Computer Interface,” for information pertinent to the safe use of the laser when the remote module is not used.

Computer Control Functions

Through the CI, the computer can:

- turn the plasma tube current on and off,
- select current or light regulation,
- set and monitor the tube current or light output level,
- select the 2 W or 10 W power range, and
- monitor the tube fill pressure, the interlock and overcurrent status lines, and the 5 Vdc internal reference.

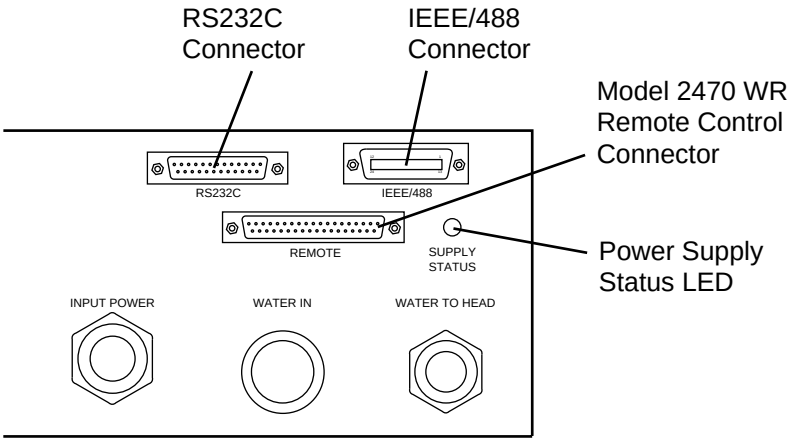


Figure 6-1: Model 2550 Power Supply Connector Panel

Installation

Usually the Model 2680 computer interface is ordered when the laser is ordered and is installed and tested at the factory. It may, however, be added at a later date and installed by the user. When ordered separately, it will come as a kit and will include:

- the computer interface pc board with a bottom shield attached,
- a 50-wire ribbon cable, and
- a 50-pin remote jumper plug.

The ribbon cable connects the CI to the power supply controller board that is located directly under the CI when it is installed. Refer to “Description” above for information on when and how to use the remote controller jumper plug.

To Install the Computer Interface:

1. Remove the power supply cover (14 screws).
2. Remove and discard the two plastic CI interface window covers.

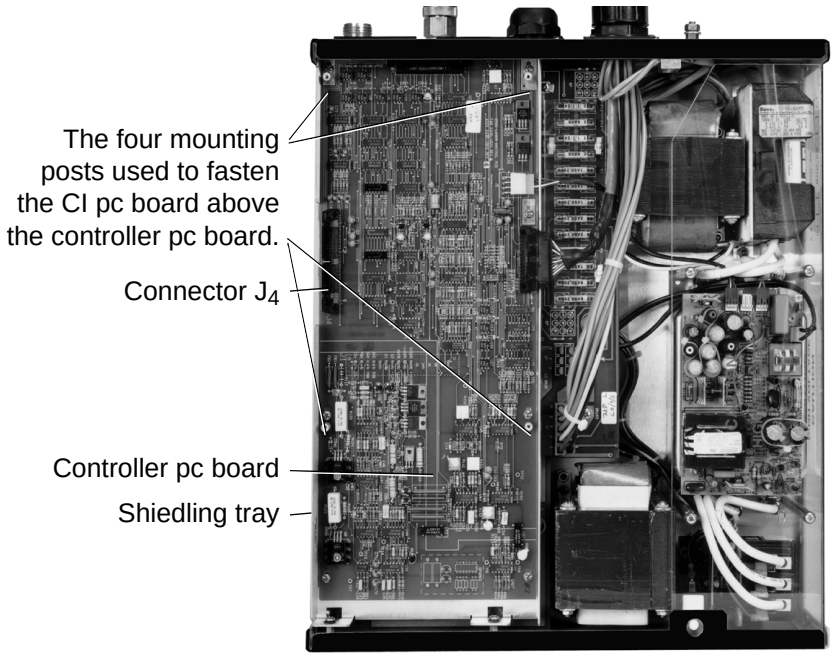


Figure 6-2: The controller pc board, mounting posts and connector J_4 shown inside the power supply shielding tray.

These are located on the connector panel of the power supply just above the REMOTE connector. The IEEE 488 and RS-232-C connectors will be accessed through these two windows.

3. Connect the 50-wire ribbon cable to the controller board.

   The controller board lies in the gold anodized shielding tray (refer to Figure 6-2). Its REMOTE connector protrudes from the power supply connector panel. Connect the cable to connector J_4. Pull the ribbon cable to the center of the controller board, and fold it at 90° so it extends past the board end opposite the REMOTE connector.

4. Place the CI pc board into the tray on top of the controller board.

   The interface connectors should protrude through their respective windows on the connector panel, and the mounting standoffs from the controller ps board should be visible through the four mounting holes on the CI pc board.

5. Using four 4-40 x $^1/_2$ in. screws and washers, mount the CI to the controller pc board (Figure 6-2).

6. Connect the remaining end of the ribbon cable to the connector on the end of the CI.
7. Refer to two following sections below for information on setting the dip switches for each interface. When this is done, install the power supply cover.

RS-232 Serial Interface Configuration Switch Settings (SW_1)

Both the CI and the host system connected to the RS-232-C connector must be configured to send and receive data at the same rate. Refer to Figure 6-3, Table 6-1 and Table 6-2 to set DIP switches SW_1 and SW_2.

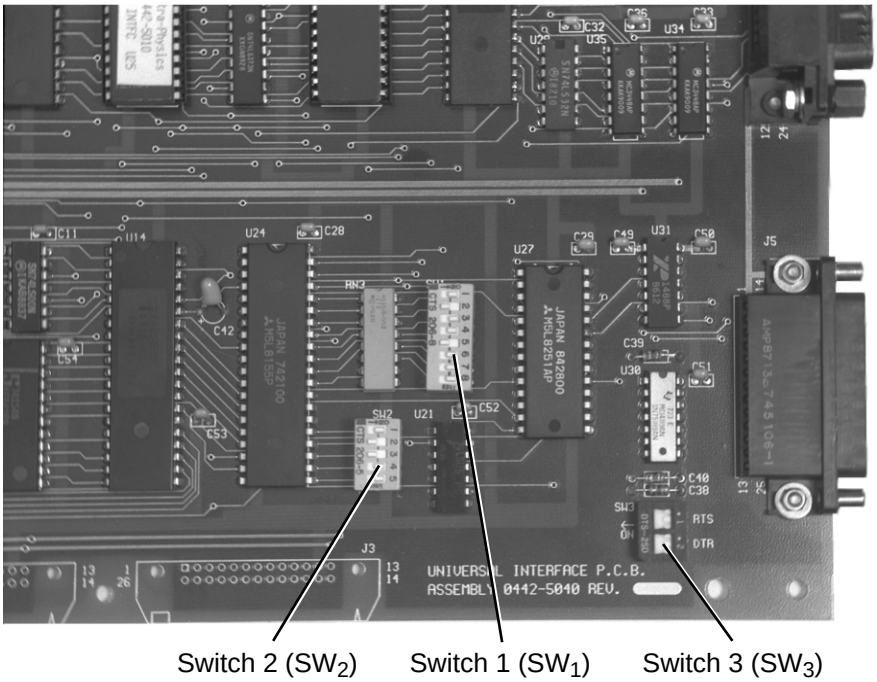


Figure 6-3: The Model 2680 Computer Interface showing DIP switches SW_1, SW_2 and SW_3.

Positions 5 through 8 of SW_1 set the bit transmission (baud) rate for the CI. Match the controller baud rate to the chosen CI rate. The factory default setting for the CI is 4800 baud.

There are also three data format settings on the two communications devices that must match: character length, parity, and stop bit(s). SW_1 positions 1 through 4 set these parameters. The factory default setting is 8-bit character length, parity disabled (odd/even is ignored), and 2 stop bits.

Table 6-1: SW_1 BAUD Rate Settings

Switch Number	Switch Position								
5	Off	Off	Off	Off	Off	Off	Off	Off	On
6	Off	Off	Off	Off	On	On	On	On	Off
7	Off	Off	On	On	Off	Off	On	On	Off
8	Off	On	Off	On	Off	On	Off	On	Off
Baud Rate	75	110	150	300	600	1200	2400	4800	9600

Table 6-2: SW_1 Mode Select Settings

Switch Position	Switch Position	Condition	Switch Position	Condition
1	Off	Parity Disabled	On	Parity Enabled
2	Off	Odd Parity	On	Even Parity
3	Off	One Stop Bit	On	Two Stops Bits
4	Off	Seven Bits per Character	On	Eight Bits per Character

IEEE-488 Device Address Switch Settings (SW_2)

The IEEE-488 interface is easy to configure.

1. Remove the power supply cover (14 screws) to expose the CI pc board (Figure 6-3).
2. Select a device address that is different from that of all the other devices attached to the same bus and, referring to Table 6-3, set SW_2 to set the IEEE-488 address from 0 to 31.

   The five positions add together to establish the address. The factory default setting is 25.
3. Replace the cover on the power supply when done.

Table 6-3: SW_2 DIP Switch Settings for Selecting Device Address

Switch Number	1	2	3	4	5
Bit Weight	16	8	4	2	1
Factory Setting (25)	On (16)	On (8)	Off	Off	On (1)

DTR/RTS Settings (SW_3)

Some computers or terminals ignore the Data Terminal Ready (DTR) signal or the Request To Send (RTS) signal, or both signals. If this is the case with your system, to enable communications between the two devices, force the appropriate line high by setting the switches on SW_3 (Figure 6-3) to the “on” (or closed) position. For more information, refer to the section on “RS-232-C” later in this chapter.

Commands

The CI is a data acquisition and control board. Only five commands are needed to perform all control and monitoring functions in the power supply:

- **CONFIGURE**—initializes the CI for computer use after system power-up.
- **WRITE**—turns plasma current on or off, selects current or power mode, and selects the 2 W or 10 W power range.
- **READ**—monitors the plasma tube gas level, the interlocks, and the over-current status lines.
- **SET**—sets the current or power output level.
- **SAMPLE**—measures tube voltage and current, and the + 5 Vdc reference signal.

The following sections, "Status Commands" and "Control Commands," explain how to use these commands to query system status and control system functions.

Status Commands

SAMPLE a

The SAMPLE a command, where *a* is a value of 1 to 4, queries four system monitors. The value returned is a decimal number from 0 to 250. Use the following equation to determine the value of the system function measured:

$$V = \frac{\text{response x multiplier}}{250}$$

where *V* is the actual value of the system function measured, *response* is the value returned by the SAMPLE a command, and *multiplier* is the value from Table 6-4 for the system function polled.

Note that the value returned for the SAMPLE 3 command depends on the power range set (see "Control Commands: WRITE p, n" below).

Table 6-4: SAMPLE a

Command	System Monitor	Range	Multiplier
SAMPLE 1	Tube voltage	0 to 300 Vdc	300
SAMPLE 2	Tube current	0 to 50 A	50
SAMPLE 3	Output power	0 to 2 W or 0 to 10 W	2 10
SAMPLE 4	+5 Vdc reference	0 to 5 Vdc	5

READ a

The READ a command, where *a* is “4” or “5”, queries the status of the eight system functions shown in Table 6-5 and Table 6-6. A decimal number from 0 to 15 is returned, representing a 4-bit binary pattern.

Table 6-5: READ 4

Decimal No. Returned	Water Temperature	Water Flow	Head Cover	Power Range
0	Not Okay	Not Okay	Open	2 W
1	Not Okay	Not Okay	Open	10 W
2	Not Okay	Not Okay	Closed	2 W
3	Not Okay	Not Okay	Closed	10 W
4	Not Okay	Okay	Open	2 W
5	Not Okay	Okay	Open	10 W
6	Not Okay	Okay	Closed	2 W
7	Not Okay	Okay	Closed	10 W
8	Okay	Not Okay	Open	2 W
9	Okay	Not Okay	Open	10 W
10	Okay	Not Okay	Closed	2 W
11	Okay	Not Okay	Closed	10 W
12	Okay	Okay	Open	2 W
13	Okay	Okay	Open	10 W
14	Okay	Okay	Closed	2 W
15	Okay	Okay	Closed	10 W

Table 6-6: READ 5

Decimal No. Returned	Fill Status	Key Interlock	Over Current Interlock	Auxiliary Interlock
0	Okay	Open	Open	Open
1	Okay	Open	Open	Closed
2	Okay	Open	Closed	Open
3	Okay	Open	Closed	Closed
4	Okay	Closed	Open	Open
5	Okay	Closed	Open	Closed
6	Okay	Closed	Closed	Open
7	Okay	Closed	Closed	Closed
8	Low	Open	Open	Open
9	Low	Open	Open	Closed
10	Low	Open	Closed	Open
11	Low	Open	Closed	Closed

Table 6-6: READ 5 (cont.)

Decimal No. Returned	Fill Status	Key Interlock	Over Current Interlock	Auxiliary Interlock
12	Low	Closed	Open	Open
13	Low	Closed	Open	Closed
14	Low	Closed	Closed	Open
15	Low	Closed	Closed	Closed

Of these responses, only four are commonly observed:

- 7—is the "okay" response from READ 5; all interlocks are closed and the fill level is okay, i.e., the system is operating properly.
- 15—shows the interlocks are closed but the fill level is low.
- 3, 5, or 6—is returned if one of the interlocks opens (usually the key switch) and shuts down the system. Although more than one interlock can be open, typically there is only one interlock open.

Note

If an interlock fault occurs and the remote jumper plug is used, or if the over-current fault occurs, turn off the main power to the system, then turn it back on to reset the interlock. The CI must then once again be initialized before it can be used (refer to "Power Supply ON Default Condition: Initializing the Interface" later in this chapter).

- Alternating "7" and "15" @ 1 Hz—indicates all interlocks are closed but the reservoir is perceived empty, or there is a mechanical malfunction. The response will toggle at 1 Hz between "7" and "15." To read this condition, use a computer program subroutine to perform a continuous asynchronous read over a 3 second period, or sample the CI at random using a terminal.

Warning!

If this last condition occurs, tube plasma is well below its normal operating level. This may signify the end of tube life. However, if there is merely a mechanical malfunction, e.g., someone disconnected the control wire to the fill solenoid, the tube will be needlessly destroyed. Turn the system off and immediately call your Spectra-Physics Lasers service representative.

Control Commands

SET p, n

The SET p, n command, where *p* is 1 or 2 and *n* is a decimal number from 0 to 250, sets either the tube current level (*p* = 1) or the desired optical output power (*p* = 2). Prior to sending this command, the control mode (current or power) and range (if *p* = 2) must be selected (see "WRITE p, n" and Table 6-7 below).

Example

SET 1, 0 = 0 A
SET 1, 125= 25 A
SET 1, 250= 50 A

	2 W Range	10 W Range
SET 2, 0 (min)	0 W	0 W
SET 2, 250 (max)	2 W	10 W

WRITE p, n

The WRITE p, n command, where *p* is 6 or 7 and *n* is a decimal or binary number listed in Table 6-7, controls three system functions. WRITE 6, n sets the power range and control mode. WRITE 7, n turns the laser on or off, and *n* is specified as a decimal number from 0 to 13.

Table 6-7: WRITE p, n

Command	Power Range	Control Mode
WRITE 6, 0	10 W	Power
WRITE 6, 1	10 W	Power
WRITE 6, 4	10 W	Current
WRITE 6, 5	10 W	Current
WRITE 6, 8	2 W	Power
WRITE 6, 9	2 W	Power
WRITE 6, 12	2 W	Current
WRITE 6, 13	2 W	Current
WRITE 7, 0 = Laser on		
WRITE 7, 1 = Laser off		

Power Supply On Default Condition

Unless the remote jumper plug (provided) is connected to the REMOTE connector, the system uses the REMOTE connector on the power supply as its primary interface, even if the power supply contains a CI pc board. Therefore, the Model 2670 remote control (or a custom control device attached to this connector) has primary control. The CI becomes the control device only when the CONTROL switch on the remote is set to IEEE-488/RS232. Otherwise, its controls are disabled. If the jumper plug is attached to the REMOTE connector, the CI has primary control, but it must be initialized prior to use (refer to "Initializing the Interface" below).

To use the Computer Interface

1. Set the MODE switch on the Model 2670 remote control to IEEE 488/RS-232.
2. If a custom control device is used instead of the Model 2670, set pin 3 of the REMOTE connector to 5 Vdc (logic level high) or allow it to float.
3. Initialize the CI.

Initializing the Computer Interface

The CONFIGURE command is unique because it is only used at system start-up to initialize the CI. Four CONFIGURE commands must be sent followed by two WRITE statements (refer to "Control Commands") to perform the initialization and to disable the REMOTE connector. Once initialized, only a computer or terminal connected through one of the CI interfaces can control the power supply.

These must be the first six lines of code in order to properly initialize the CI:

```
PRINT #1, "CONFIGURE 4, INPUT, NONCLOCKED"
PRINT #1, "CONFIGURE 5, INPUT, NONCLOCKED"
PRINT #1, "CONFIGURE 6, OUTPUT, NONCLOCKED"
PRINT #1, "CONFIGURE 7, OUTPUT, NONCLOCKED"
PRINT #1, "WRITE 6, 12"
PRINT #1, "WRITE 7, 1"
```

The CI is now initialized to these settings:

Interface:	computer
Plasma control:	off
Mode:	current
Power range:	2 W

Refer to your IEEE-488 controller manual for specific hardware set-up information and to your BASIC manual (GW BASIC, BASICA, or QuickBASIC) for information on BASIC command statements. Other programming languages may also be used.

IEEE 488 Interface

Operation

The IEEE-488 interface conforms to the ANSI/IEEE standard 488-1978 and comprises a user-supplied bus controller and from 1 to 32 I/O devices that are defined and addressed by the controller as *talkers*, *listeners*, or *talker-listeners*. This bus is often referred to as the GPIB (General-Purpose Interface Bus) or the HPIB (Hewlett-Packard Interface Bus).

Talkers are input devices that can only monitor events and send data to the controller, e.g., digital voltmeters. They "talk" to the controller. Conversely, listeners are output devices that "listen" to the controller and send signals from it to the real world, e.g., digital to analog converters (DACs). Talker-listeners operate in both directions, and the CI is just such a device. When the CI is properly programmed, the controller will execute data transfers to and from it via the IEEE-488 bus.

Command strings sent from the controller to the CI need to be terminated by a comma (,) or line feed (<LF>). Unlike some IEEE-488 interfaces, the CI does not require the END command to terminate messages to it (refer to "Message Formats" below).

Nevertheless, to conform with controllers programmed to recognize the END command, the CI sends it to terminate all data transfers from the CI.

Remote Reset

The CI can be reset to the power-on default state any time by sending it either a Device CLear (DCL) or Select Device Clear (SDC) bus message, or InterFace Clear (IFC) bus reset. Refer to "Power supply On Default Condition" above and to your controller's user manual for details.

Note

After receiving a DCL or SDC command or IFC signal, the CI takes about 0.5 seconds to reinitialize. Therefore, the controller must not send messages to the CI during this time. Programs will require a delay routine immediately following any reset command.

Serial Poll Status Byte

The CI responds to the IEEE-488 controller's Serial Poll Enable (SPE) message by returning a status byte indicating (i) the execution status of the last command received, and (ii) the version number of the CI firmware (used for factory diagnostic purposes). Figure 6-4 shows the composition of the status byte. This status byte is provided primarily to facilitate error masking and recovery. This feature is standard on all IEEE-488 controllers.

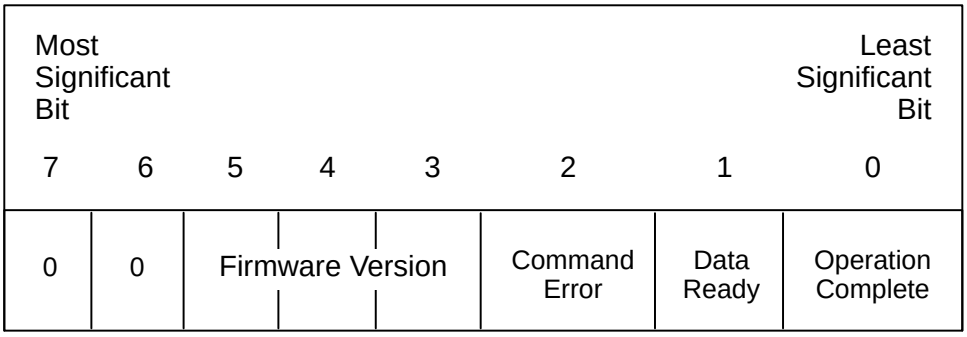


Figure 6-4: Diagram of the serial poll status byte indicating the function of each bit.

Bit 0 is high (1) after the CI finishes executing a command. It is low (0) during the execution of a command.

Bit 1 is high when the CI has finished executing a SAMPLE or READ command, and response data is ready for output to the controller. It is low after the CI has finished sending the response to the controller. (The SAMPLE and READ commands are defined in the "Commands" section above.)

Bit 2 is high after an error is detected in the command line and the CI has aborted the command.

Bits 3, 4, and 5 indicate the firmware version as a three-bit binary number. Bit 5 is the most significant bit.

Bits 6 and 7 are always zero.

The IEEE-488 controller performs a serial poll of the CI by executing an SPE command. The CI will automatically respond by sending back the status byte.

Note

Each IEEE-488 controller manufacturer has its own way of querying the input device for the serial status byte. Refer to your IEEE–488 controller hardware manual for samples of BASIC statements that can be used.

The following is a BASIC statement used by the *IO-Tech Personal 488 GPIB Controller Card*:

```
.
.
Print #1, "SPOLL"
Input #2, A$
.
```

Print is a BASIC output statement. The controller attached to the CI has been designated device #1 for output. SPOLL is the SPE command that causes its controller to request a status byte. Refer to your IEEE-488 controller manual for specific I/O device setup information and command language.

Input is a BASIC input statement. The controller attached to the CI has been designated device #2 for input, even though only one controller card is likely to be used for both input and output. The requested status byte is read into the IEEE-488 controller as BASIC variable "A$."

RS-232-C Interface

Operation

The RS-232-C interface standard classifies serial I/O devices as either Data Terminal Equipment (DTE) or Data Communications Equipment (DCE). The standard further identifies a serial connector as a 25-pin, D-sub type, with the pins providing various data and control signals. When IBM™ introduced the IBM PC-AT, they introduced a new serial port standard, this time using a 9-pin, D-sub connector. This made some sense, because serial devices rarely used all 25 pins—most only used 3. The IBM version is now a defacto standard for PC-compatible computers and peripherals, although the 25-pin variety can still be found on many systems.

Although the signals are well defined for the 9-pin standard, the same is not true of the older 25-pin "standard." And, unfortunately, manufacturers of serial I/O devices have provided incompatible definitions. As a result there is no guarantee that any two devices will communicate with each other until all hardware and data format settings have been configured to match the requirements of the mating device.

The serial interface of the CI is an RS-232-C compatible interface configured to emulate DCE equipment using 25-pin connectors. Signal inputs and outputs of the serial interface are likely to be compatible with most computers and terminals configured as DTE equipment. If the CI is connected to another DCE device, a cable adapter that switches the data signal lines, pins 2 and 3, and control signal lines, pins 4 and 5, is usually all that is needed to make the devices compatible.

Table 6-8 shows the signals and interconnections that are used by the CI. The data link signals are named relative to the DTE.

Table 6-8: Standard RS-232-C Interconnections

Terminal (DTE)			RS-232-C Link	CI (DCE)	
STD 25PIN		**PC-AT 9 PIN**			
TXD	(2)	(3)	Transmitted Data	(2)	RXD
RXD	(3)	(2)	Received Data	(3)	TXD
RTS	(4)	(7)	Request To Send	(4)	CTS
CTS	(5)	(8)	Clear To Send	(5)	RTS
DSR	(6)	(6)	Data Set Ready	(6)	DTR
DCD	(8)	(1)	Data Carrier Detect	(8)	DCD
DTR	(20)	(4)	Data Terminal Ready	(20)	DSR
	(7)	(5)	Signal Ground	(7)	
	(1)	(SHELL)	Protective Ground	(1)	

Data Transfer and Handshaking

The RS-232-C serial interface operates in the full duplex mode: data may be sent and received simultaneously. To synchronize data transmissions with the host system, the CI implements a simple hardware handshaking protocol and monitors and controls the interface signals in the manner described below. Interface signals are named relative to the DTE device.

Data Terminal Ready (DTC) and Request To Send (RTS)—the CI checks both of these lines when it has response data to send. It sends data only when both signals are high (1).

Data Set Ready (DSR), Clear To Send (CTS) and Data Carrier Detect (DCD)—the CI keeps these lines high at all times; thus, it is always ready to receive commands from the host system.

Message Formats

Command Format

Information in this section applies for both the IEEE-488 and RS-232-C interfaces.

The commands, as shown earlier, are strings of ASCII characters the computer or terminal sends the CI. The string consists of the command word and one or two data elements:

<command word><data><LF>
<command word><data>,<data><LF>

For each command word, the CI expects to find appropriate data or keyword elements following it. Data is always in **integer** form and must be in the range from 0 to 255 when in decimal format, or 0000b to 1111b when in binary format (refer to "Commands" earlier in this chapter).

Commands and keywords are reserved words that have unique meaning to the CI and can only be used for narrowly defined purposes.

A command string also includes the comma (,) and line feed (<LF>) delimiter characters to separate command elements and to terminate each command. These delimiters may be used interchangeably. Typically the comma is used between elements of a command with <LF> used to terminate the command. The delimiter between the command word and the element(s) following it may be omitted.

Command words and keywords might contain either upper or lower case alpha characters. Spaces and all nonprintable characters (except <LF>) are ignored by the CI. Consecutive delimiters are interpreted as a single delimiter; all but the first are ignored.

Examples:

SET 1, 127<LF>
SET,2,255<LF>
WRITE4,1001B,WRITE5,0110B<LF>

The use of delimiters permits simple message formatting, allowing entry from either a terminal or computer program.

When entered from a terminal, they may take the following form:

SET 1, 127 <CR><LF>

If executed from a program, they may look like this:

```
10 A$ = "SET"
20 B = 1
30 C = 127
40 OUTPUT A$,B,C
```

Command words and keywords may be abbreviated (Table 6-9), but they must include at least the first three characters. Whether spelled out or abbreviated, they must be spelled correctly or they will be aborted.

Table 6-9: Computer Interface Command Abbreviations

Command Word	Shortest Abbreviated Form Acceptable
CONFIGURE	CON
READ	REA
SAMPLE	SAM
SET	SET
WRITE	WRI
Keywords used with the CONFIGURE Command	
INPUT	INP
OUTPUT	OUT
NONCLOCKED	NON

An input error occurs if any part of the command is invalid, e.g., a misspelled command word or keyword, a data value out of range, or an incorrect number of elements in the command. When this happens, the CI aborts and waits for a new command and bit 2 of the IEEE-488 interface status byte register is set high (1).

Response Format

After executing a SAMPLE or READ command, the CI sends the requested data to the computer followed by a carriage return and line feed:

<response> <CR> <LF>

The CI also sends the END message to terminate transmission if the IEEE-488 interface is used.

Programming Example (Written using BASICA)

The example program on the following page continuously runs the Stabilite 2018 through the following seven minute plasma on and off cycle:

Minute	Plasma	Current
1	on	high
2	on	low
3	on	high
4	on	modulated
5	on	high
6	off	
7	off	

```
10   CLS
20   PRINT “MODEL 2550 TEST”
30   OPEN “COM:78N2D” FOR OUTPUT AS #1      Initialize RS-232 port to 4800 baud, 8-bit
                                            character, no parity, 2 stop bits, XON/XOFF
                                            disabled
40   PRINT#1, ””                            Clear CI RS-232 port
50   PRINT#1, “WRITE 6, 4”                  Initialize CI port 6
60   PRINT#1, “WRITE 7, 1”                  Initialize CI port 7
70   PRINT#1, “CONFIGURE 6, OUT, NON”       Configure CI port 6
80   PRINT#1, “CONFIGURE 7, OUT, NON”       Configure CI port 7
90   PRINT#1, “SET 1, 255”                  Set current control high
110  PRINT#1, “WRITE 7, 0”                  Turn on plasma
120  GOSUB 310                              Wait 1 min
130  PRINT#1, “SET 1, 100”                  Set current control low
140  GOSUB 310                              Wait 1 min
150  PRINT#1, “SET 1, 255”                  Set current control high
160  GOSUB 310                              Wait 1 min
170  FOR X = 1 to 400                       Start 1 min modulation
180  PRINT#1, “SET 1, 255”                  Set current control high
190  FOR Y = 1 to 25                        Delay
200  NEXT Y
210  PRINT#1, “SET 1, 100”                  Set current control low
220  FOR Y = 1 to 25                        Delay
230  NEXT Y
240  NEXT X                                 End modulation loop
250  PRINT#1, “SET 1, 255”                  Set current control high
260  GOSUB 310                              Wait 1 min
270  PRINT#1, “WRITE 7, 1”                  Turn off plasma
280  GOSUB 310                              Wait 2 min
290  GOSUB 310
300  GOTO 110                               Repeat 7 min cycle
310  FOR X = 1 to 21700                     1 min delay subroutine
320  NEXT X
330  RETURN
340  END
```

Chapter 7 Maintenance

The condition of the environment and the amount of time the laser is used will affect your periodic maintenance schedule. Optics will obviously stay clean much longer if not exposed to smoke or other air-born contaminants. Condensation due to excessive humidity can also contaminate the optical surfaces. Try to provide a smoke-free, filtered, dry environment for the laser. The cleaner the environment, the slower the rate of contamination.

Notes on the Cleaning of Laser Optics

Ion lasers are oscillators that operate with gain margins of a few percent. Losses due to unclean optics, which might be negligible in ordinary optical systems, can disable a laser. Dust on mirror surfaces can reduce output power or cause total failure. Cleanliness is, therefore, essential. The maintenance techniques used with laser optics must be applied with extreme care and with attention to detail.

“Clean” is a relative description; nothing is ever perfectly clean, and no cleaning operation ever completely removes contaminants. Cleaning is a process of reducing objectionable materials to acceptable levels.

Since cleaning simply dilutes contamination to the limit set by solvent impurities, solvents must be as pure as possible and leave as little solvent on the surface as possible. As any solvent evaporates, it leaves impurities behind in proportion to its volume. Avoid re-wiping a surface with the same lens tissue; a used tissue and solvent will redistribute contamination, they won’t remove it.

Always use fresh solvent. Both methanol and acetone collect moisture during prolonged exposure to air. Avoid storage in bottles where a large volume of air is trapped above the solvent. Instead, store solvents in small glass bottles where either the solvents are used up quickly or the bottles are filled frequently from a fresh, uncontaminated source.

Laser optics are made by vacuum depositing microthin layers of materials of varying indices of refraction on glass substrates. If the surface is scratched to a depth as shallow as 0.01 mm, the operating efficiency of the optical coating will be reduced significantly.

Because an intracavity passive catalyst is used in the Stabilite 2018 laser, there should be little requirement for optical cleaning if the cavity is left closed and undisturbed. However, because optics are exchanged from time to time, there will be occasions when cleaning is necessary.

Stick to the following principles whenever you clean any optical surface.

- Remove and clean one optic at a time, then replace it and optimize laser output power. If more than one optic is removed at at time, all reference points will be lost, making realignment extremely difficult.
- Perform any maintenance in a clean environment, over an area covered by a soft cloth or pad, if possible.
- Wash your hands thoroughly with liquid detergent. Body oils and contaminants can render otherwise fastidious cleaning practices useless.
- Use dry nitrogen, canned air, or a rubber squeeze bulb to blow dust and lint from the optic surface before cleaning it with solvent. Permanent damage may occur if dust scratches the coating.
- Use spectrophotometric-grade (HPLC) solvents. Don't try to remove contamination with a cleaning solvent that may leave other impurities behind.
- Use powder-free, clean latex gloves or finger cots.
- Use Kodak Lens Cleaning Paper™ or equivalent to clean optics and plasma tube windows. Use each piece only once: a dirty tissue merely redistributes contamination, it does not remove it.

Warning!

Do not use lens tissue that is designated for cleaning eye glasses. Such tissue contains silicones. These molecules bind themselves to the mirror coatings and window quartz and can cause permanent damage. Also, do not use cotton swabs, e.g., Q-Tips™. Solvents dissolve the glue that is used to fasten the cotton to the stick, and the result is contaminated coatings. Only use photographic lens tissue to clean optical components.

Equipment Required

Some of the following are supplied in the accessory kit.

- dry nitrogen, canned air, or rubber squeeze bulb
- plastic hemostat
- $^{1}/_{16}$ in. hex driver
- clean (new) finger cots or powder-free latex gloves
- Kodak Lens Cleaning Paper,™ or equivalent

Danger!

Do not use a metal hemostat or forceps for cleaning optics or windows. There is danger of electrocution when using these instruments inside the laser head. Use the plastic hemostat provided.

Cleaning Solutions Required

- spectrophotometric-grade (HPLC) acetone or methanol

Caution!

Only use spectrophotometric-grade acetone and/or methanol. Using lower grade reagents may lead to contaminateion of or damage to optical coatings.

Note

Methanol tends to clean better but, if not fresh, may deposit a water-based film on the surface being cleaned. If this occurs, follow the methanol wipe with an acetone wipe to remove the film. As always, use fresh solvent from a bottle with little air in it.

General Procedures for Cleaning Optics

The laser should be on and stable. Remove, clean, and replace one optic at a time, maximizing laser output power after each optic is cleaned. Use clean finger cots to protect all intracavity components, including the coated mirror surface.

Do not allow the cavity to remain open for very long. The intracavity passive catalyst that reduces O_3 in the cavity will become contaminated and, therefore, ineffective. Keep the output coupler and high reflector locked in place, and make sure the tubular cavity seals are in place. Following these simple rules will ensure a long catalyst life.

The high reflector can be left in its holder for cleaning. However, the output coupler (OC) and the beam splitter must be removed from their holders to clean the second surface.

1. Use a squeeze bulb, dry nitrogen, or canned air to clean away any dust or grit before cleaning optics with solvent.

Drop and Drag

2. Whenever possible, clean the optic using the “drop and drag” method (Figure 7-1).

    a. Hold the optic horizontal with its coated surface up. Place a sheet of lens tissue over it, and squeeze a drop or two of acetone or methanol onto it.

    b. Slowly draw the tissue across the surface to remove dissolved contaminants and to dry the surface.

    Pull the tissue slow enough so the solvent evaporation front immediately follows the tissue, i.e., the solvent dries only after leaving the optic surface.

Figure 7-1: Cleaning the Mirror Surface

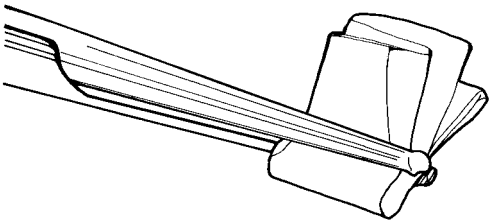


Figure 7-2: Lens Tissue Folded for Cleaning

Tissue in Hemostat

3. For stubborn contaminants and to access hard-to-reach places (such as the windows), use a tissue in a hemostat to clean the optic.

    a. Fold a piece of tissue in half repeatedly until you have a pad about 1 cm (0.5 in.) square, and clamp it in a plastic hemostat (Figure 7-2).

Don't Touch!

While folding, *do not touch* the surface of the tissue that will contact the optic, or you will contaminate the solvent.

---

    b. If required, cut the paper with a solvent-cleaned tool to allow access to the optic.

    c. Saturate the tissue with acetone or methanol, shake off the excess, resaturate, and shake again.

d. Wipe the surface in a single motion.

   Be careful that the hemostat does not touch the optic surface, or the coating may be scratched.

4. After placing the optic you just cleaned into the beam, inspect it to verify the optic actually got cleaner, i.e., you did not replace one contaminant with another.

Cleaning Mirrors

During the following cleaning procedure, acetone is referred to, but methanol can be used as well.

1. Close the shutter.
2. Remove the high reflector holder.
3. Clean the coated surface following the “Drop and Drag” procedure as outlined under “General Procedures for Cleaning Optics,” Steps 1 and 2, above.
4. Install the mirror holder.
5. Open the shutter.
6. Adjust the mirrors vertically and horizontally for maximum optical output power.
7. Close the shutter.
8. Remove the output coupler.
9. Remove the optic from its holder (simply pull it out), and clean the output surface following the “Drop and Drag” procedure.
10. Place the optic back into its holder.

    The arrow on the side of the optic points to the coated side which must face the cavity.

11. Clean the cavity surface in the same manner.
12. Install the mirror holder.
13. Open the shutter.
14. Adjust the mirrors vertically and horizontally for maximum optical output power.

This completes the procedure for cleaning the mirrors.

Cleaning the Prism Assembly

The laser should be on and stable.

1. Remove the prism assembly from the laser.

Caution!

Do not leave the optical cavity of the laser open for extended periods of time. Doing so shortens the life of the intracavity passive catalyst.

---

2. Unscrew and remove the cover of the prism assembly.
3. Remove the high reflector.

   A small retaining screw (Figure 7-3) holds the mirror spring clip in place. Loosen the retaining screw and slide the spring clip to the side. *Do not adjust any other screws on the prism assembly, and do not touch the optic or its holder with your fingers; wear clean finger cots or powder-free latex gloves.* Invert the assembly and drop the mirror onto a soft, lint-free surface.

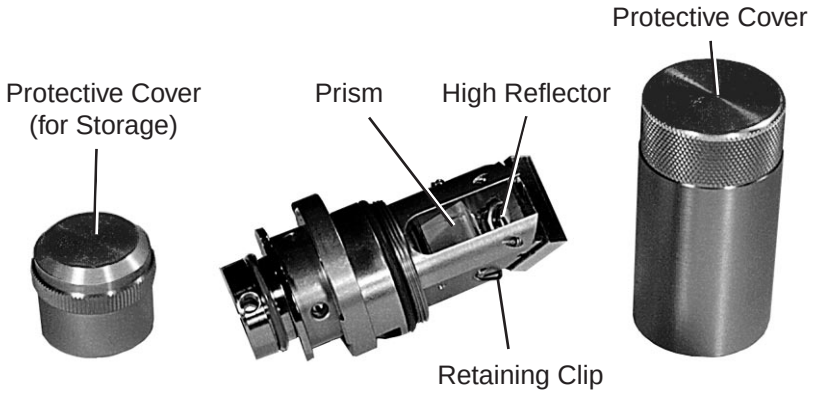


Figure 7-3: Stabilite Single-line Prism Assembly

4. Clean the high reflector.

   Clean the coated surface following the “Tissue in Hemostat” procedure as outlined under “General Procedures for Cleaning Optics,” Step 3.

5. Install the high reflector in its holder.

   The arrow on the barrel of the optic points to the coated surface and should face the cavity. Once the mirror is in the holder, slide the retaining spring back into place.

6. Clean the prism.

Leave the prism in place, it can be cleaned in its mount. Clean the coated surface following the "Tissue in Hemostat" procedure as outlined under "General Procedures for Cleaning Optics," Step 3.

a. Wipe one surface—bottom to top—in a single motion. Be careful that the tip of the hemostat does not scratch the surface.

b. Repeat this procedure *with a fresh tissue* on the second prism surface.

   A clean prism surface will scatter little or no light when the laser is operating.

7. Screw the prism cover back over the prism assembly.
8. Install the prism assembly in the laser.
9. Open the shutter.

Danger!
Laser Radiation

If the prism assembly is installed with its cover off, a portion of the intracavity beam is reflected upward (Figure 7-4) from each face of the prism. Avoid eye contact with these beams.

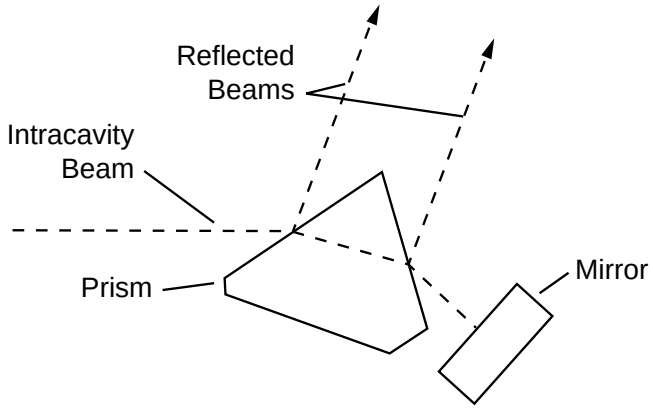


Figure 7-4: A portion of the intracavity beam is reflected upward from each face of the prism.

10. Adjust the high reflector vertically and horizontally for maximum optical output power.

This completes the procedure for cleaning the prism assembly optics.

Cleaning Plasma Tube Windows

Danger! Laser Radiation

The following procedure requires removing the laser head cover and defeating its safety interlock. Dangerous laser radiation is accessible when the cavity seals are pulled back; therefore, permit only trained personnel to service and repair your laser system.

Warning!

If specified power cannot be achieved after an acetone or methanol/acetone cleaning of all optical components, stop. Further scrubbing may damage the surface. Call your Spectra-Physics Lasers service representative.

Warning!

Perform the following procedure only if, after the mirrors have been cleaned and the output power maximized, the laser still does not meet specified power.

1. Turn off the laser.
2. Expose the windows.

Don't Touch!

Do not touch the interior of any intracavity components with your fingers, including the endbell shroud. Contaminants left on these surfaces will migrate to the windows later. Always wear clean, powder-free latex gloves or finger cots.

Slide the cavity seals toward the plasma tube until the windows are totally exposed. Remove the dust tube if you need to by unscrewing it from the mirror mount.

3. Clean the windows.

   Clean the coated surfaces following the “Tissue in Hemostat” procedure under “General Procedures for Cleaning Optics,” steps 1 and 3, above. Wipe windows—bottom to top—in a single motion. Be careful that the tip of the hemostat does not scratch the surface.

Caution!

Do not let solvent wick between the window and the shroud (Figure 7-5).

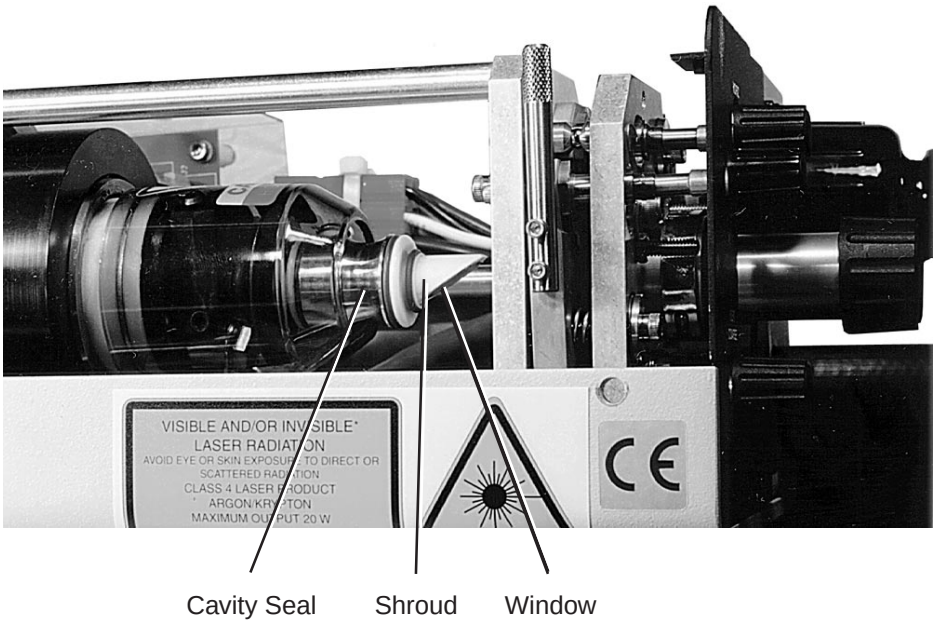


Figure 7-5: Plasma Tube Endbell Showing Shroud and Window

4. Check output power level.

   Restart the laser and allow it to warm up. If the laser meets specified power, stop—you are done. If it does not meet specified power, call your Spectra-Physics Lasers service representative.

This completes the procedure for cleaning the windows.

Replacing the Water Filter

A filter housing and cartridge is shipped with each system. The housing is light blue with a black cover and it should have been installed in the plumbing that provides water to the Stabilite 2018 laser system.

1. Shut off the water supply.

   Shut off the return line as well if you are using a closed-loop cooling system.

2. Place a bucket or container under the filter to catch any spilled water.
3. Press the button on top of the filter cover to release internal pressure.
4. Unscrew the lower blue filter housing from the assembly.
5. Remove the used, filament-wound filter.
6. Make sure the O-ring in the cover is clean and is seated evenly in its groove.

7. Insert a new filter into the housing. Verify the new filter is a 25 µm filter. Use a Spectra-Physics Lasers filter (P/N 2604-0070) or equivalent.
8. Screw the housing into the cover.
9. Open the return line, then slowly turn on the water while checking for leaks.

This completes the procedure for replacing the water filter.

Cleaning the Power Supply Water Filter Screen

Clean the filter in the power supply female hose fitting frequently. It is a small, round, mesh screen.

1. Shut off the water supply.

   Shut off the return line as well if you are using a closed-loop cooling system.
2. Remove the inlet hose from the female fitting on the power supply.
3. Using a pair of tweezers or forceps, grasp the edge of the screen and pull it out. Grasp the edge only; if the tool punctures the mesh screen, the filter will no longer be effective.
4. Invert the filter and hold it under a forceful water stream to remove trapped debris. Then run water on both sides of the screen.
5. Carefully slip the screen back into place with your finger, being careful not to push against the screen. Make sure it is securely seated.
6. Install the inlet hose.
7. Open the return line, then slowly turn on the water while checking for leaks.

This completes the procedure for cleaning the filter screen.

Chapter 8 Service and Repair

Vertical Search Alignment Procedure

If your instrument fails to lase, the most likely source of the problem is a severely misaligned high reflector. The following technique allows you to readily restore lasing.

1. Shut off the laser.
2. Remove the top cover from the laser head, and install the interlock defeat key.
3. Open the shutter.
4. Open the aperture fully ("○" on the scale).
5. Restart the laser and allow it a few minutes to warm up again.
6. Use an Allen driver to turn the coarse vertical adjustment (lower screw) two turns counterclockwise.
7. Perform vertical search alignment (Figure 8-1).
   a. Grasp the search bar on the left side of the mirror plate with your left hand and use a second Allen driver to turn the horizontal coarse adjust (top right screw). Rock the mirror plate quickly while simultaneously turning the coarse horizontal adjustment very slowly.
   b. Keep rocking and scanning until you observe a bright flash of laser light.

      When the beam flashes, stop turning the horizontal control. Turn the vertical adjustment clockwise until you establish sustained lasing.
   c. Adjust both the vertical and horizontal controls on the high reflector for maximum power.
   d. If you do not see a flash and you are convinced you will never achieve lasing going in this direction, turn the horizontal adjustment in the other direction and repeat this procedure from step b.

Danger!
Laser Radiation

The following procedures require removal of the laser head cover and defeat of its safety interlock. Dangerous laser radiation is accessible when cavity seals are pulled back; therefore, permit only trained personnel to service and repair your laser system.

Danger!
Laser Radiation

Use appropriate caution and wear appropriated eyewear whenever the laser cover is removed and cavity seals are pulled back, exposing the laser beam.

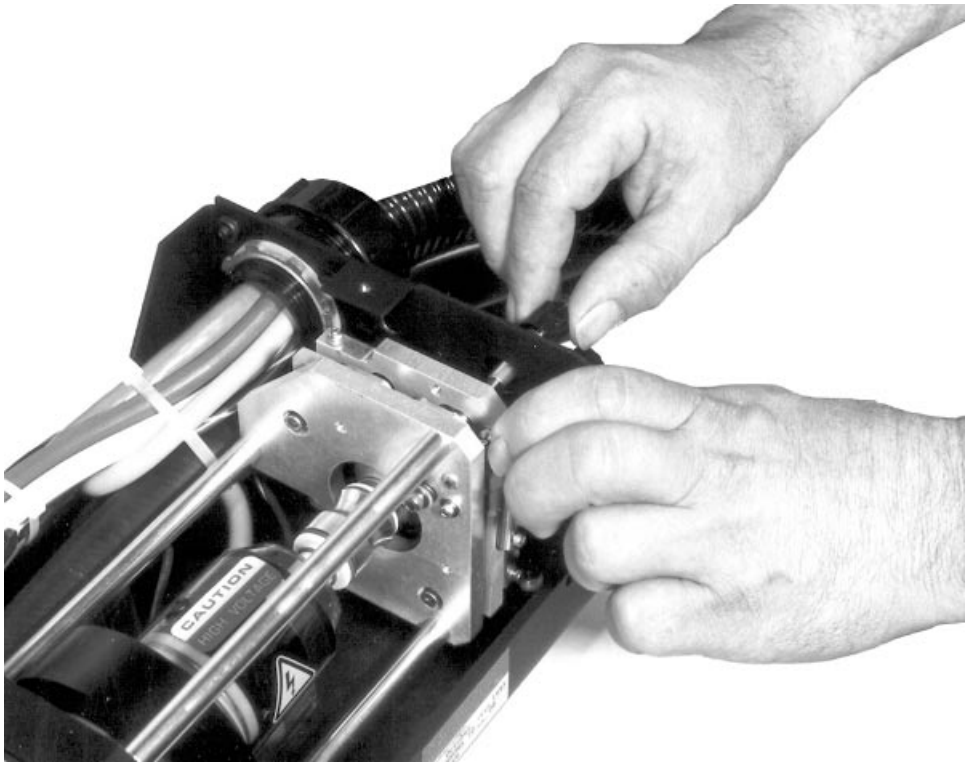


Figure 8-1: Vertical Search Technique

Laser Head Alignment

The Stabilite 2018 resonator is designed so the center of the aperture and the centers of both mirror mounts lie on the same line—the resonator axis. In order for the laser to provide optimum performance, three conditions must be met:

- the line defined by the plasma tube bore must be centered on the resonator axis;
- the flat high reflector must be normal to the resonator axis;
- the center of curvature of the output coupler must be on the resonator axis.

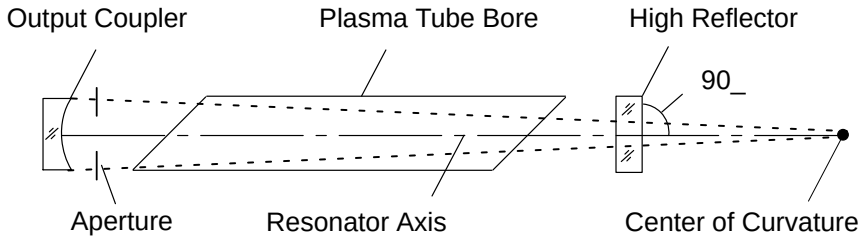


Figure 8-2: Schematic Representation of Ideal Resonator Alignment

Your laser is factory aligned and, under normal operating conditions, should only require the preventive practices described in Chapter 7, “Maintenance,” to meet its performance specifications. If you discover a significant drop in power, the source of the problem is probably one of the following:

- Contaminated (dirty) optics
- Misaligned mirrors
- Misaligned plasma tube

The procedures in this section allow you to solve these problems, thereby returning your laser to optimum performance. They are listed in the order you should perform them. The most probable cause of poor performance is contaminated optics; they should be cleaned before you try anything else. If the problem persists after cleaning the mirrors, clean the plasma tube windows. Then align the mirrors. Finally, if all else fails, align the plasma tube.

If the laser has been cleaned and aligned and you are sure that it is producing maximum power, but its performance remains below specification, call your Spectra-Physics Lasers service representative.

Adjusting the Mirrors for Apparent Maximum Power

Patience and attention to detail are required to assure proper alignment. First, adjust the laser for apparent maximum power. Then “walk” the beam along the parallel mirrors until you have satisfied yourself, by trial and error, that no additional power can be coaxed from the unit.

1. Insert a hex driver in the coarse horizontal adjustment of the high reflector.
2. Monitor output power while you turn the control. Turn it back and forth until output power is as high as possible.
3. Similarly, adjust the vertical coarse control.
4. Repeat these adjustments, first turning one control, then the other, back and forth until the power reaches its maximum.

5. Repeat this procedure using the fine mirror adjustments. Note the output power.

"Walking the Mirrors" to Assure Maximum Power

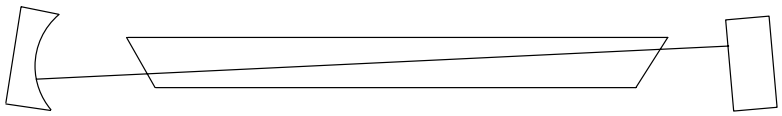


Figure 8-3: Misaligned Mirrors Allow Lasing at Reduced Power

Figure 8-3 illustrates an arrangement of cavity mirrors that will allow lasing, but with reduced output. A slight tilt of the high reflector compensates for a similar tilt of the output coupler. The resulting beam is skewed with respect to the resonator axis and the plasma tube bore. Under these conditions the laser can be "peaked," but the output will be less than optimum because part of the beam is obstructed by the bore walls and/or the aperture.

Walking the mirrors is a trial and error procedure that assures optimum mirror alignment. The goal is to align the intracavity beam with the resonator axis by making small adjustments of the high reflector and matching them with adjustments of the output coupler. By observing the change in output power as you move the mirrors, you will find the optimal alignment positions.

1. Set the aperture to "3."

   Aligning the beam to a large aperture allows the intracavity beam to be aligned slightly off-center to the aperture. Later, when a smaller aperture is used, it is possible for the intracavity beam to be nonsymmetrically clipped.

2. Walk the mirrors to achieve maximum output power.

   Adjust the high reflector for maximum power, then use its vertical coarse adjustment to detune the output to 30% – 60% of its maximum value. Next, adjust the vertical control on the *output coupler* in the opposite direction, i.e., if the high reflector control was turned clockwise, turn the output coupler control counter-clockwise.

   Be careful! Only adjust one set of controls at a time. If the laser stops lasing, reverse the direction of mirror movement until lasing is restored.

3. Observe the change in output power as you turn the output coupler control.

   a. If the output maximum exceeds the original value, walk the mirrors in the same direction again. Repeat until the power reaches its maximum.

b. If output fails to reach the original value, walk the mirrors in the opposite direction.

4. Adjust the high reflector for maximum power.
5. Repeat this procedure using the horizontal coarse controls.

   Always find the maximum power with one set of controls before moving to the other set, i.e., finish with the vertical controls before you move the horizontal controls. Always adjust the high reflector for maximum power before changing from one set of controls to the other.
6. Repeat this procedure using the horizontal coarse control.

Troubleshooting

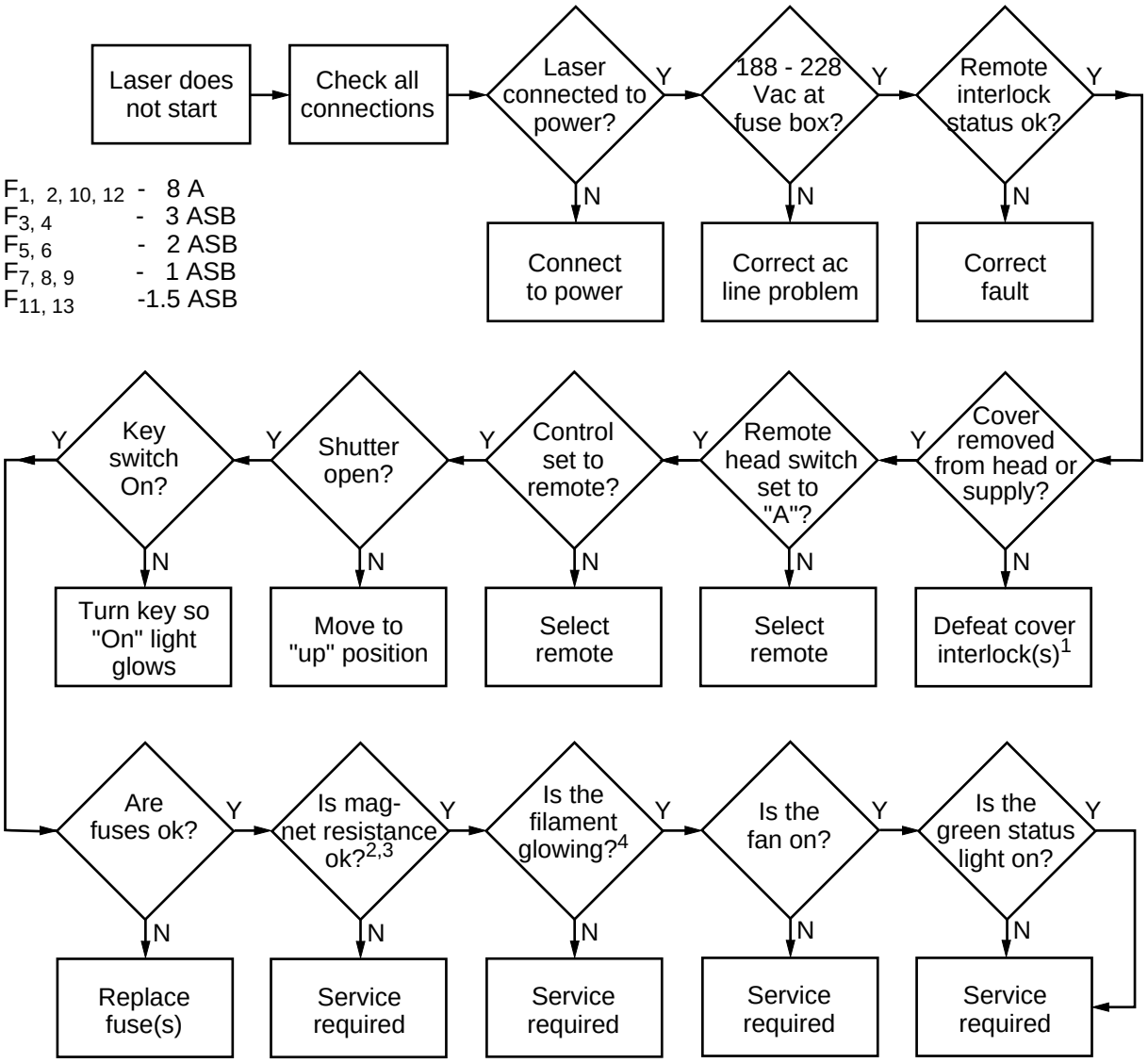
The troubleshooting guide is provided to assist in isolating some of the problems that might arise in the power supply or laser head. A complete repair procedure is beyond the scope of this manual. For information concerning repair by Spectra-Physics Lasers, see Chapter 9, “Customer Service.”

Danger!

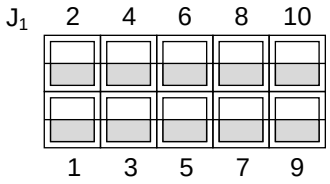
The laser head and power supply contain electrical circuits operating at high voltages. Whenever access to the interior of the laser head or power supply is necessary and laser operation is required, exercise extreme caution to avoid contact with high voltages. These high voltages are lethal.

Table 8-1: Troubleshooting

Symptom	Things to Check
Low output power	Dirty optics or plasma tube windows. See corresponding sections in Chapter 7, “Maintenance.”
	Incorrect optics. Check that the optics in the laser are coated for the wavelength you are using.
	Error in setting. Check for correct current setting, and make sure that the aperture and shutter are both open. Be sure you are tuned to a strong line and that the power range setting is not limiting the power output if you are in power control mode.
	Plasma tube or mirrors misaligned. See “Mirror Alignment” or “Plasma Tube Alignment.”
Maximum current too low	Possible plasma level too high. Check the tube voltage on the remote control. If the voltage is over 228 V, contact your Spectra-Physics Lasers service representative.
	Possible low line voltage. If the line voltage is below 188 V, maximum current may not be available.
Laser fails to start or plasma discharge ceases	Possible open interlock. Check the water flow, water pressure and water temperature. Also check laser head and power supply interlocks.



1 Defeat the power supply interlock switch by pulling up on the plunger.
2 *Warning:* Disconnect power before performing this step.
3 Magnet resistance across Pins 2 and 4 of laser head cable J_1 should be 68 Ω ±1% (see connector drawing below). Resistance from either pin to ground should be >10 MΩ.
4 *Danger:* Remove the high reflector to stop the lasing action before looking down the bore.



J_1 is located on the power supply main board. To read the magnet resistance, disconnect the multi-component plug from J_1 and use an ohm meter to read the resistance across the wires going to the laser head (pins 2 and 4).

Figure 8-4: Troubleshooting Diagram

Replacement Parts

Table 8-2: Replacement Parts List (Preliminary)

Description	Part Number
Fuse, 2 A, slow blow (F_5, F_6)	5100-3024
Fuse, 3 A, 250 V (F_3, F_4)	5101-0610
Fuse, 8 A, 250 V (F_1, F_2, F_{10}, F_{12})	5101-1020
Fuse, 1.5 A, 250 V (F_{11}, F_{13})	5101-1290
Fuse, 1 A, 250 V, ceramic (F_7, F_8, F_9)	5101-1430
Fuse, 50 A, 250 V, (main power fuses)	5101-1440
Water filter cartridge	2604-0070
Shipping container, Stabilite 2018 laser head	0450-4570
Shipping container, Model 2550 power supply	0432-5400

Chapter 9 Customer Service

At Spectra-Physics Lasers, we take pride in the durability of our products. Considerable emphasis has been placed on controlled manufacturing methods and quality control throughout the manufacturing process. Nevertheless, even the finest precision instruments will need occasional service. We feel that our instruments have favorable service records compared to competitive products. We hope to demonstrate, in the long run, that we provide excellent service to our customers in two ways. First, by providing the best equipment for the money, and second, by offering service facilities that restore your instrument to working condition as soon as possible.

Spectra-Physics Lasers maintains major service centers in the United States, Europe, and Japan. Additionally, there are field service offices in major United States cities. When calling for service inside the United States, dial our toll-free number: **1 (800) 456-2552.** To phone for service in other countries, refer to the Service Centers listing located at the end of this section.

Order replacement parts directly from Spectra-Physics Lasers. For ordering or shipping instructions, or for assistance of any kind, contact your nearest sales office or service center. You will need your instrument model and serial numbers available when you call. Service data or shipping instructions will be promptly supplied.

To order optional items or other system components, or for general sales assistance, dial **1 (800) SPL-LASER** in the United States, or **1 (650) 961-2550** from anywhere else.

Warranty

This warranty supplements the warranty contained in the specific sales order. In the event of a conflict between documents, the terms and conditions of the sales order shall prevail.

The Stabilite 2018 system is protected by an 18-month/2000 hour warranty. All mechanical, electronic, and optical parts and assemblies, including plasma tubes, are unconditionally warranted to be free of defects in workmanship and material for the warranty period.

Liability under this warranty is limited to repairing, replacing, or giving credit for the purchase price of any equipment that proves defective during the warranty period, provided prior authorization for such return has been given by an authorized representative of Spectra-Physics Lasers. Warranty repairs or replacement equipment is warranted only for the remaining unexpired portion of the original warranty period applicable to the repaired or replaced equipment.

This warranty does not apply to any instrument or component not manufactured by Spectra-Physics Lasers. When products manufactured by others are included in Spectra-Physics Lasers equipment, the original manufacturer's warranty is extended to Spectra-Physics Lasers customers. When products manufactured by others are used in conjunction with Spectra-Physics Lasers equipment, this warranty is extended only to the equipment manufactured by Spectra-Physics Lasers.

Spectra-Physics Lasers will provide at its expense all parts and labor and one way return shipping of the defective part or instrument (if required).

This warranty does not apply to equipment or components that, upon inspection by Spectra-Physics Lasers, discloses to be defective or unworkable due to abuse, mishandling, misuse, alteration, negligence, improper installation, unauthorized modification, damage in transit, or other causes beyond Spectra-Physics Lasers' control.

The above warranty is valid for units purchased and used in the United States only. Products with foreign destinations are subject to a warranty surcharge.

Warranty extensions for incremental 6-month/750 hour periods can be purchased before the expiration date of any prior warranty.

Warranty Return Procedure

Contact your nearest Spectra-Physics Lasers field sales office, service center, or local distributor for shipping instructions or an on-site service appointment. You are responsible for one-way shipment of the defective part or instrument to Spectra-Physics Lasers.

We encourage you to use the original Spectra-Physics Lasers packing boxes to secure instruments during shipment. If shipping boxes have been lost or destroyed, we recommend that you order new ones. Spectra-Physics Lasers will only return instruments in Spectra-Physics Lasers' containers.

Warning!

Always drain the cooling water from the laser head before shipping. Water expands as it freezes and will damage the laser. Even during warm spells or summer months, freezing may occur at high altitudes or in the cargo hold of aircraft. Such damage is excluded from warranty coverage.

Service Centers

Australia

Spectra-Physics Pty. Ltd.
25 Research Drive
Croydon, Victoria 3136
Telephone: (03) 761-5200
Fax: (03) 761-5600

Benelux

Spectra-Physics B.V.
Prof. Dr. Dorgelolaan 20
5613 AM Eindhoven
The Netherlands
Telephone: (40) 2 65 99 59
Fax: (40) 2 43 99 22

France

Spectra-Physics SARL
Z.A. de Courtaboeuf
Avenue de Scandinavie
91941 Les Ulis Cedex
Telephone: (01) 1 69 18 63 10
Fax: (01) 1 69 07 60 93

Germany and Export Countries*

Spectra-Physics GmbH
Siemensstrasse 20
D-64289 Darmstadt-Kranicshstein
Telephone: 06151 7080
Fax: 06151 79102

Japan

Spectra-Physics K.K.
East Regional Office
Daiwa-Nakameguro Building
4-6-1 Nakameguro
Meguro-ku, Tokyo 153
Telephone: (03) 3794 5511
Fax: (03) 3794 5510

** All European and Middle Eastern countries in this region not included elsewhere on this list.*

Service Centers *(cont.)*

United Kingdom

Spectra-Physics Ltd.
Boundary Way
Hemel Hempstead
Herts, HP2 7SH
Telephone: (01442) 25 81 00
Fax: (01442) 68 538

United States and Export Countries**

Spectra-Physics Lasers
1330 Terra Bella Avenue
Post Office Box 7013
Mountain View, CA 94039-7013
Telephone: 1 (800) 456-2552 (Service)
1 (800) SPL-LASER (Sales) or
1 (800) 775-5273 (Sales), or
1 (650) 961-2550 (Operator)
Fax: 1 (650) 964-3584

** *All countries in this region not included elsewhere on this list.*

Notes

Spectra-Physics Lasers User's Manual– Problems and Solutions

We have provided this form to encourage you to tell us about any difficulties you have experienced in using your Spectra-Physics Lasers instrument or its manual—problems that did not require a formal call or letter to our service department, but that you feel should be remedied. We are always interested in improving our products and manuals, and we appreciate all suggestions.

Thank you.

From:

Name _____

Company or Institution _____

Department _____

Address _____

_____

Instrument Model Number _____ Serial Number _____

Problem: _____

_____

_____

_____

_____

Suggested Solution(s): _____

_____

_____

_____

_____

_____

Mail To:

Spectra-Physics Lasers, Inc.
Ultrafast Lasers Systems Quality Manager
1335 Terra Bella Avenue
Mountain View, CA 94043
U.S.A.

e-mail: sales@splasers.com
http://www/splasers.com

FAX To:

Attention: Ultrafast Laser Systems Quality Manager
(650) 967-1651